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THE BRASSFOUNDER'S MANUAL

INSTRUCTIONS FOR

MODELLING, PATTERN-MAKING, MOULDING, ALLOYING, TURNING, FILING, BURNISHING, BRONZING, ETC., ETC.

CONTAINING COPIOUS RECEIPTS AND TABLES, AND NOTES ON PRIME COSTS AND ESTIMATES

With Numerous Illustrations

By WALTER GRAHAM

Tenth Edition

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PREFACE TO THE FIRST EDITION

THESE pages appear in type for the purpose of supplying the felt want, and of gratifying the universal desire among Brassfounders, for such a production.

The author has been careful not to enlarge the Manual beyond a cost accessible to all workmen. In accomplishing this, greater space has been devoted to those particulars in which workmen are considered most defective, and consequently less space has been assigned to other well-known processes.

British, American, and Continental works have supplied some of the author's materials; which, with the original matter, will, it is hoped, improve and benefit those for whom the treatise is intended.

PREFACE TO THE SECOND EDITION.

THE First Edition of this little work was written simply to meet local requirements. It is, however, gratifying to find that it took a wider range of usefulness, which is evidenced by a demand for another edition.

There has recently been published in Germany some account of a few processes for bronzing brass, very similar to those which seven years ago were proposed in the First Edition of this book. These have been added, together with such new matter as will tend to increase the value of the work, every page of which has been carefully revised.

PREFACE TO THE SEVENTH EDITION.

THE sale of this little book having been steadily maintained, the publishers have taken the opportunity of a new Edition being called for to add a table of the new Imperial Standard Wire Gauge, prepared by the Iron and Steel Wire Manufacturers' Association, and another useful table giving the Properties of Materials, by various authorities.

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THE

BRASSFOUNDER'S MANUAL.

ON THE GENERAL CONSTRUCTION OF A BRASS-FOUNDRY.

In erecting new works, or altering old ones, many things require to be considered in order to save time and labour in the process of manufacturing, as well as to save expense in the first cost.

It is always good economy to employ a properly qualified person, acquainted with the whole details of the business, to furnish plans for new or altered works—though there is often some difficulty in obtaining an individual so qualified.

We lay down the following general principles, in the hope that they will prove useful to those who may have to construct a brass-foundry.

Very much depends upon the extent of the works required. For moderate purposes there will be required—

A warehouse, including offices, &c.
A pattern shop and pattern room.
A moulding shop.
A casting shop.
A dressing room.
A finishing shop.
A dipping and colouring room.
A lacquering room.

The sizes of all the shops and rooms must be left to the judgment of the employer, who alone knows the class of work he purposes carrying on, and the extent of space required for his several operations.

It is exceedingly desirable that a view of all the interiors of the shops should be had from the warehouse, if possible. Connected with the warehouse should be a store-room and packing-hall.

The Pattern Shop and Pattern Room are usually connected, yet distinct. Both must be accessible from the warehouse. The pattern room is best lighted from the roof, in order to give the largest amount of wall space. Abundance of light is essential in this room. In the pattern shop a few side windows are desirable, as lines are better seen by side light than by roof light.

It is common to have both Moulding and Casting Shops in one, and for a small work the plan is well enough; but where a dozen moulders are employed, it is better to divide the work and separate the shops, in which case the floors should not be on the same level, but the casting-shop floor should be 2 feet

6 inches above the level of the moulding-shop floor. This arrangement prevents all stooping on the part of the men when removing the flasks from the benches or tubs to the floor of the casting shop. The moulders never enter the casting shop, but simply place the flasks on the casting-shop floor, through openings in the partition dividing the shops. The moulding shop should therefore be narrow, so as to give the men but a short distance to carry the flasks from the benches to the casting-shop floor. The moulding shop must be well lighted. This is done best from above, immediately over the tubs. The tubs are usually placed along the whole length of the shop; but where space is valuable, more moulds can be accommodated by placing the tubs at right angles to the wall, two being placed back to back, as desks are in a counting-house. The sand-cellar should be as near the centre of the shop as possible, with a shoot from the outside, so as to save any further carrying. In the moulding shop are placed the drying stove and core stove; and, if possible, these should be heated by means of steam jackets, so as to save fires in the moulding shop. This plan has also the advantage of keeping the place much cleaner. A water-tap and sink inside this shop is a great convenience.

The Casting Shop should be of the same length as the moulding shop. The furnaces are best placed

midway between the ends of the shop, and on the opposite side from the moulding shop. On the one side of the furnaces should be the coke cellar, with a shoot from the outside. On the other side, the ash cellar. Near the spot where the boxes are poured, gratings should be placed, on which the boxes are to be emptied, the sand passing by an inclined plane back into the moulding shop. One of the most important things to be attended to in the construction of a casting shop is its ventilation. There should be openings at the floor-level and in the roof, so as to create a current.

The Dressing Room must adjoin the casting shop, so that all the castings can be easily handed over, on being weighed, for the purpose of removing the grates and dressing the castings, which in turn are handed into the warehouse and again weighed. Hence the necessity of having the dressing room adjoining the warehouse. The size of this room need not be large, and all the furniture required for it is a bench with a few vices.

The Finishing Shop is one on which there is a great variety of opinions. It should, however, be roomy, rectangular, and well lighted, either from the roof or from the sides. Most people prefer the benches round the walls, and the lathes, &c., in the centre of the floor; others prefer the benches short, and at right angles to the wall, the workmen are

placed in pairs, back to back, one lathe is placed at the end of each bench, and the vertical, buffs, &c., in the centre of the floor. Others, again, would place the benches in the centre of the shop, leaving the walls for the other tools. Some will have the lathes all driven from below, so as to show no belting above, while others disapprove altogether of this plan, and prefer the older method of driving all from above. These are matters which must be left very much to individual judgment.

The Dipping and Colouring Room must adjoin the finishing shop, and open into it. It must be well supplied with water and sinks, and have abundance of ventilation. If possible, let the light be from the north.

The Lacquering Room must have a window opening into the finishing shop, and a door or window opening into the warehouse. It must be so constructed as to be perfectly free from smoke. It must also be kept free from dust, and should be lighted from the north, and be well ventilated.

MODELLING AND PATTERN-MAKING.

Modelling and Pattern-making are distinct branches of business. They are also distinct from that of a brassfounder; but, though distinct, yet they are as essential to him as the bending of glass tubes and the construction of glass apparatus are to the chemist. Where work is divided, and every one has his own department to perform, like so many parts of an engine, it may matter little whether or not he can put his hand to modelling and making of patterns; but, in a country where small workshops abound, it is of importance that the general principles of modelling and making of patterns be well understood. Such particulars are here given as will prevent a workman from appearing bewildered when questioned on or required to perform some little work pertaining to either branch.

The materials commonly employed for modelling are pipeclay and stucco. The former is used for work of a protracted nature, the latter for straight flat models which can be finished off at once. Pipeclay, which is decomposed felspar, is made into a putty with water or glycerine: the glycerine prevents its getting hard for a considerable time.

Almost the only tools required for modelling

(save some thin brass wire for cutting and dividing, such as is used for cutting soap or cheese) are represented in Fig. 1. They are made of box-wood.

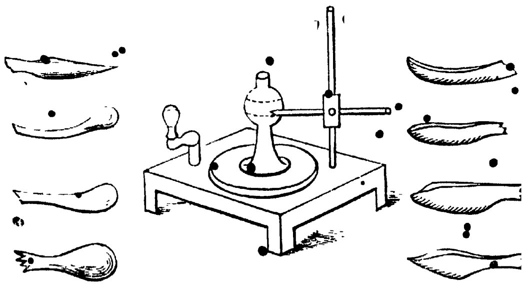

Fig. 1.—Horizontal Lathe and Modelling Tools.

They are represented one-fourth size. The handles are 6 inches long; the sharpest edges are slightly nicked; the others are all more or less blunt.

The horizontal lathe or turning-table represented in Fig. 1 will be understood from the woodcut. It is provided with a tool-rest; in revolving the handle on the left, it operates on pulleys below, and turns the circular table on which the model is placed. It will be found exceedingly useful for circular work.

A few nicely planed boards, of various sizes, are always in requisition. On these boards an outline of scroll or other work is drawn, the clay placed thereon and modelled.

Clay is modelled with the hand and wood tools, mostly by pressure. The clay adheres to wood, or the turning-table, when slightly moistened, and requires no other fixture. A very little practice will enable a man of ordinary abilities to accomplish much in this material, which would take greater expense and longer time to fashion in wood.

Models, made either in clay or wood, and which are intended for immediate use, require to be made larger than the size given, by one quarter of an inch to every foot. For this purpose, it is best to construct a measure or rule properly divided, so as to save time and calculation.

Should it be required, however, to make a metal pattern from the clay or wood, then the shrinkage will be double, and the model will require to be made half an inch larger per foot every way, a second measure or rule being required. The real shrinkage is only three-sixteenths, but the other sixteenth is allowed for finishing.

Patterns exactly rectangular do not draw well from the sand; hence all patterns should be made with a taper of at least one-eighth of an inch to every foot.

Sharp internal angles should be avoided, as they leave an arris on the sand, which requires mending.

It is often necessary, in model-making, to take impressions and casts from existing works which

cannot be dismantled or cut up. For this purpose, the impression is usually taken in gutta percha, which is to a certain extent flexible when cold. The best mode of softening the gutta percha is by applying the heat from the front of a fire. It is sometimes more convenient to warm it in hot water, and as soon as the impression is taken, place it in cold water until cold; gutta percha always contracts unless put into cold water. Stucco is also much employed; or, better, a composition of

1 part yellow wax,
4 parts black rosin.

When much relief or coreing is required, a flexible mould can be made of

12 parts glue,
3 parts treacle,

the treacle being applied after the glue is melted, in the usual way.

Mr. Overman of Philadelphia enumerates sulphur, bread-crumbs, glass, alum, saltpetre, &c., as materials for taking impressions and casts.

Wood patterns should be varnished or painted, so as not to absorb moisture. All patterns, if brushed with black lead, like a grate, will leave the sand more freely, and save considerable mending.

A great saving is often effected in making patterns of mouldings or bends by sweeping them up in stucco. The process is almost exactly the same

as that described under "Loam-moulding." It is not essential to have all patterns exactly of the thickness of the casting wanted, as it is often cheaper to take a thickness off the pattern in manner afterwards explained.

MOULDING.

THE APPARATUS AND MATERIALS.

BRASSFOUNDERS' furnaces are mostly sunk under the floor level; the pit for the removal of the ash is covered by hinged iron gratings. The covers for the furnace-top are constructed of cast iron, and usually dome-shaped, though not necessarily; a damper is inserted in the flue to regulate the draft. The internal building of the furnace is of fire-brick, grotted with fire-clay.

In large works, it is common to have an air-furnace, instead of the ordinary one (Fig. 2). The difference exists in the admission of a blast under the furnace bars, and stopping up the ordinary opening at the ash-pit. The blast is obtained from a patent fan, driven by the engine.

Throughout the country there are almost an endless quantity of small brass-foundries, where the

regular furnace cannot be applied. The stove-furnace (Fig. 3), or a modification of it, is generally

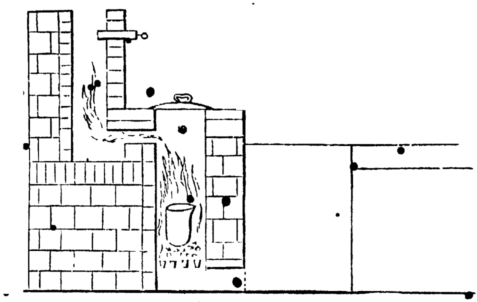

Fig. 2.—Ordinary Melting Furnace.

adopted. The third furnace (Fig. 4) is only intended for small work; it is extremely clean, and

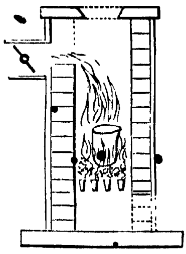

Fig. 3.—Stove Furnace.

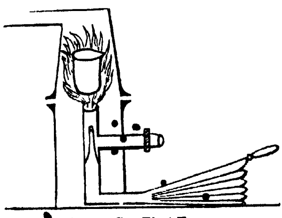

Fig. 4.—Gas-Blast Furnace.

can be used on a bench; the kneed-pipe over the crucible is made of fire-clay. The heat from this furnace is most intense.

In passing, it may be well to explain that fire-clay is a compound of silica, alumina, and water, mixed to a greater or less extent with foreign substances. The bricks are made from pounded clay, in other respects like ordinary bricks. The foreign matters are chiefly oxide of iron, lime, magnesia, black lead, and bitumen. These contaminations impair the value of the clay, and render it less fit for standing fire. Pure clay is white, opaque, and unctuous.

Next in importance to the furnaces are the crucibles; these should not corrode, should not allow liquids or gases to pass through them, and should resist every sudden change of temperature.

The common crucibles are made from

1 part fire-clay,
2 parts black lead.

The Berlin crucibles consist of

8 parts fire-clay,
4 parts black lead,
5 parts powdered coke,
3 parts old ground crucibles.

The Stourbridge crucibles are composed of

4 parts fire-clay,
2 parts burned-clay cement,
1 part ground coke,
1 part ground pipe-clay.

Mr. Austey's patent crucibles contain

2 parts fire-clay,
1 part ground gas-coke.

The crucibles in general use are known as *blue pots;* they consist chiefly of fire-clay and black lead; they are manufactured either as pottery-ware, on a wheel, or by mould and mandrel. The materials should be free from lime, and wrought as compacted as possible, and slowly dried in a kiln.

When fire-clay cannot be had, common clay, steeped in hot hydrochloric acid, and well washed with hot water, and dried, may be substituted.

CRUCIBLE TONGS.

Fig. 5 exhibits the forms of tongs best suited for furnace-work. The great object is to hold the

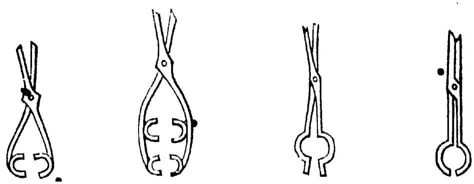

Fig. 5.

crucible fast. These tongs should be strong, and of various sizes.

FUEL.

Hard coke is generally employed for brassfounders' furnaces and stoves. Coke should leave only a small per-centage of ash, and should practically convert six to eight pounds of water into steam, for every one

pound of coke consumed. Much larger quantities are commonly published, but they relate to theoretical quantities, making no allowance for the lost heat which passes up the chimney. Gas-coke is also very much employed; it has the advantage of cheapness.

DRYING-STOVE.

Fig. 6 exhibits a drying-stove, half open; the fire is placed on the lower grating: the air is admitted

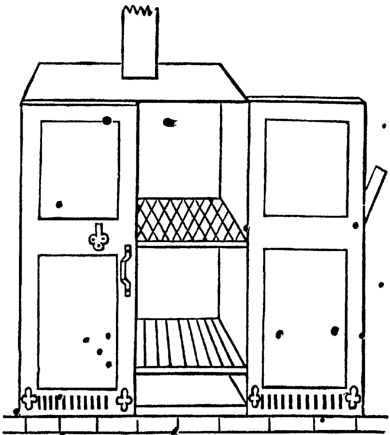

Fig. 6.

through openings at the foot of the doors, or from under the doors when made a little shorter than the size; the mould-boxes and cores are placed on the

upper grating, and the draft conducted to the flue on the top of the stove. The doors are made of iron, the other three sides of stone or brick. The size will depend on the extent of work. Drying-stoves are beneficial, on account of so much damp sand and loam being used by the moulders; their use produces sounder and sharper castings, as will be explained under "Sands."

A much cleaner stove is obtainable by making a steam-tight jacket for the stove, and so heating it with the exhaust steam from the engine. This saves space and all the fuel for this stove, as well as the time wasted in attending to it. In this case the stove must be made wholly of iron.

For small cores it is exceedingly convenient to have an ordinary range-oven, mounted with a steam-jacket or case in the same way, and supplied with steam also from the exhaust. Care must be taken, however, to let the steam have an outlet.

MOULDING-TUB AND TOOLS.

The construction, nature, and application of the respective parts of the apparatus given in Fig. 7 will be apparent at a glance. The moulding-tub requires to be made very strong; it is constructed of wood, and provided with sliding bars, and a quantity of one-inch boards, with cross ends, the size of the moulding-boxes. The moulding-boxes are simply

rectangular rims of iron, with snugs and pins exactly fitted, so that when the one half is placed upon the other there will be no possibility of shifting a hair's-breadth. The cramps are made of wood, sufficiently long to clasp the moulding-boxes lengthwise

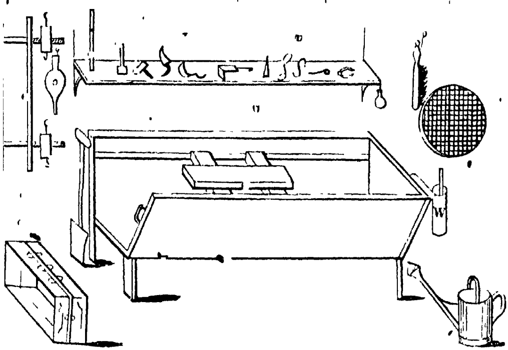

Fig. 7.

When the boxes are large, several bars are cast across them. When the boxes are subject to much rough work, the bars are best made of malleable iron, cast in; where lightness is desirable in large boxes, they should be entirely made of malleable iron.

SANDS AND FACING MATERIALS.

Sand.—Moulding may be executed in many substances, but none so conveniently or so perfectly as

sand, containing a little loam or clay. The greater the quantity of pure sand or silex, the more readily will the gases generated at pouring escape, the less risk of blown-holes, and the greater chance of a good casting. The greater the quantity of loam or clay, the more perfect will be the impression, but the greater risk of spoiled castings. These remarks apply only to green-sand casting, as the difficulty is altogether removed by using the drying-stove.

Sands for moulding purposes, though varying in grain, have the composition of about

94 parts silex,
4 parts clay,
2 parts oxide of iron and impurities.
———
100

Lime, magnesia, and metallic oxides are detrimental substances to the moulder, and sands containing them in any larger proportions than above should be avoided. They do not stand the heat; they melt in the presence of the poured metal; they boil, unite with and blister the surface of the casting; they generate gases, cause hosts of air-holes, and destroy more than the sand is worth.

Moulding-sand is obtained from the beds of large rivers, in the vicinity of granite or slate mountains; in the rivers of coal districts, if the iron is not too abundant; but never in mica, lime, or volcanic districts.

Core Sand.—This sand, though gritty and porous, must be adhesive, fresh, and pure. Rock sand, that is, the accumulation of washed sand, from a newly broken primitive or felspar rock, receives the preference; where this is not to be had, pounded blast-furnace cinder, tempered with a little clay, may be used; failing both, free sand, mixed with clay or barm, may be employed.

Parting Sand.—This may be either red brickdust, fresh free sand, sea or river fine sand, or blast-cinder powder. It must be a substance which does not retain damp; preference being given in the order above indicated.

Facing the Sand.—When hot metal comes in contact with fresh sand, the sand partially melts, and a rough casting is the result. To obviate this, fine charcoal is dusted upon the mould, or the mould is smoked with cork shavings or pitch torches, by which a very fine deposit of carbon is obtained, and a smooth skin secured to the casting. Carbon does not adhere well to old sand; when it is used, it is necessary, first, to dust the mould with pease-meal, and then add the carbon. Avoid excess of both, otherwise the casting will come out faint, instead of sharp, the carbon collecting in the hollows and preventing the metal running up.

MANIPULATION.

Ordinary plain work is arranged according to circumstances in the flask. Fig. 8 shows a general arrangement. When only one or two castings are

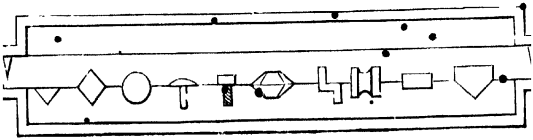

Fig. 8.

required from a pattern, the pattern is "rapped," into the flask, that is, the top part being rammed up, a portion of the sand is removed, and the pattern inserted, or "rapped in." After sprinkling on some parting sand, the drag is placed on, and facing sand sieved in, after which the ordinary sand is rammed in till the flask is full; then the flasks, top and drag, are turned over so that the drag is lowest, when the top part is taken off and emptied, the face of the drag cleaned again, and dusted with parting sand. After this, the top part is put on, and filled and rammed with facing and ordinary sand, as was done above. The top part is again removed, and the patterns withdrawn. In the process of parting the box and withdrawing the patterns it often occurs that part of the sand is torn away, which in con-

sequence requires to be mended. The greater portion of the moulder's time is taken up by this process of mending. The moulds being mended, finished, and provision made for the escape of gases and air, as well as for the admission of the metal or alloy, by gates and runners, the top and drag are put together, closed, and cramped. The mould is then immediately placed on the casting-shop floor, and poured along with other flasks. This mould, not having been dried, is called a "green sand" mould. If, however, the castings are required to be of a fine external appearance, the mould, before being closed, would have been placed in the drying-stove, and smoked.

When a large quantity of any article is required, the patterns are planted on a plate, usually iron, and the flasks are rammed up on the plate, the whole boxful of patterns being lifted out of the sand at one and the same time. There is great economy in this method. For that very reason it is disliked by some workmen, who, being on day-wages, often endeavour to set it aside, whenever it is possible, and commonly by producing a large amount of badly formed castings when plate-moulding.

It is to be regretted that so much ignorance exists among workmen on the very first principles of political economy, notwithstanding all that has been done to convince them that economy in labour

produces a larger amount of work to individual establishments or countries.

There is now working its way gradually through out the country a method of removing the plate on which the patterns are placed from the flask, after the flask has been rammed up; and, from the almost mathematical accuracy of the lift, much of the mending before referred to is avoided, and ten times the amount of work performed by one man. In fact, the attention of manufacturers at the present moment is more than ever directed to labour-saving machinery, and the time is fast approaching when the largest amount of castings will be moulded by machinery. Such a result will benefit the workmen as much as the employers, unless the present workmen refuse to work such machinery, in which case they will have to follow the example of the hand-loom weavers, which would be anything but comfortable to them. It is folly to expect the art of moulding to stand still, while all the world around is on the march of progress, and daily showing how little we knew before. and how much is to be learned, in the present and the future, before we arrive at anything like perfection.

CORES.

When a hole or opening is required to be left in a casting, a piece of baked sand, exactly the size of the hole or opening wanted, is inserted in the mould, so as to occupy the exact position of the hole or opening, and prevent the metal or alloy from running into such space. In order to keep the core in its exact place, it is made a little longer than necessary, so as to have a bearing at each end. The pattern has in consequence prints upon it, so as to leave an impression in the sand to receive this additional length. These prints are represented black in Fig. 9.

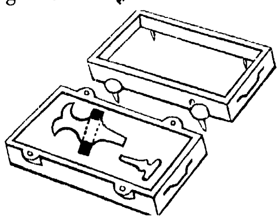

Fig. 9 - Box with Core Casting.

Many cores, however, have only one bearing, as

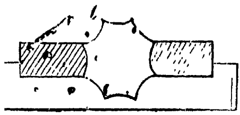

Fig. 10.—False Cores.

False Cores (Fig. 10), which are only inserted a short way into the mould, as, for example, in the fluting of a column shaft. The same thing occurs in casting some leaves (Fig. 11), or similar work.

In column capitals, richly ornamented, four, six, or eight cores are usually employed, as the case may require. Thus, from the simplest of core cast-

Fig. 11.—Leaf.

ings to the highest and most complicated, the same principle pervades, and the same plans are adopted, though often requiring considerable skill, practice, and neat manipulation.

Cores are usually made in core-boxes (Fig. 12).

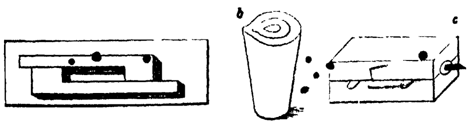

Fig. 12.—Core Boxes.

The first of the above figures (a) represents sliding bars on a wooden board for making square cores; the second (b), a tin mould for tapered cores; and the third (c), a metal box for cylindrical cores. Cores,

however, are not confined to these forms, although these are the most frequent; they consist of every form and shape, regular and irregular, plain and ornamental, of one and of several parts. It is often costly to construct core-boxes; but, as a general rule, a costly core-box can be dispensed with, by moulding the pattern in sand, and casting it solid from a composition of

1 part plaster of paris,
2 parts brickdust,
Water, q s.

and scraping down to the size required to form the core.

It is necessary that all cores should be vented, that is to say, have a hole through them, which is done in the process of making, by inserting a wire, and withdrawing it immediately before opening the core-box to take out the core. Without such vents the casting is sure to be bad, the gases having no way of escape. When the cores are large, core-irons are required to support the sand core. It is customary to support large and long cores in the centre by brass nails or chaplets. It is better, however, to avoid such, and balance the core by a heavy end on the core bar, if possible.

To give consistency to the sand used in making cores, about one-half should be pure rock sand, which contains a certain proportion of clay, but not

generally enough; hence the addition of clay-water or British gum is necessary so give the sand the proper amount of cohesiveness.

The cores must be thoroughly dried in a stove, the temperature being between 300° and 400° Fahr. After the cores are dry, they are black-washed, or coated with a mixture of ground charcoal and water, a little clay or size being added; they are returned to the stove to have this wash dried, after which they are ready for the mould. The black wash causes the core to leave the casting readily, and renders the surface of the casting next the core smooth and free from defects.

In green-sand moulds it is better not to insert the cores till within a short time before pouring, so as to prevent their absorbing moisture.

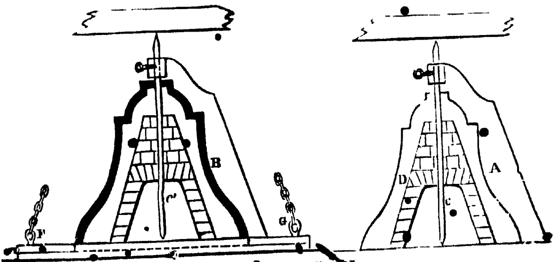

Fig 13.—Moulding Bells in Loam.

Large and heavy castings, such as large church bells, are moulded in loam.

In Fig. 13, A and B are templets; A is made to the inside shape of the bell, B to the outside. An iron lintel is thrown across at C, supported by the under and supporting the upper brickwork. The core is left for a fire to dry the building and the coating of loam D, which is placed over the building and formed by A, which revolves round with the spindle. This is faced; a coating of fresh sand, indicated by the thick black line, and swept by B, is then applied. This is also faced; B is withdrawn, and upon an iron ring, F G, a large quantity of loam is erected. When dry, the upper loam is raised by a crane; the sand picked out; the snugs, inscription, &c., which have been separately mouldea in wax or clay, are inserted; the whole dried and cast.

Statuary.—In works of Fine Art, such as statuary, a rough core is constructed of iron ribs, wire gauze, and stucco; a layer of wax, containing a little white pitch and tallow, is laid on the structure and modelled. The foregoing composition of brickdust and plaster of paris is laid on in quantity, the wax melted out, and the metal poured. But this is more within the department of the artist than of the brassfounder.

Ordnance.—Brass ordnance are cast in a manner peculiar to themselves. A wood spindle is wound with soft rope, a shade smaller than the interior

diameter of the gun; loam is applied to the rope till the proper thickness of the metal is acquired; the whole is turned to the shape or pattern of a drawing; the spindle and rope are then withdrawn; the loam dried and faced; another and thicker layer of loam is applied and dried; the first picked out; the air escape holes, which are required for every mould, being made, the gun is cast, turned, bored, and tested.

Thickness or Reverse Moulding.—When a thin casting is required from a thick pattern, the upper half of the mould is moulded from the opposite impression, and a thin sheet of clay inserted between the two half boxes, as shown by the dotted lines in Fig. 14.

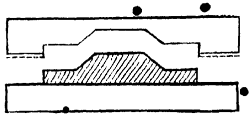

Fig. 14.—Thickness or Reverse Moulding.

Moulding Screws.—The pattern is screwed into the sand. See Fig. 8.

Odd Sides.—This term is given to the practice of taking off two impressions from the one setting of patterns, so that when the patterns are taken out, they can be placed in this third or odd side without re-arrangement.

Flowers, Insects, &c.—It is sometimes required to copy nature from natural objects, such as a butterfly

a flower, a bird, in short, anything which can be consumed by fire. The object is suspended in a box, and surrounded with a compound of brickdust and plaster of paris—two to one in water. The mould is placed in a furnace to consume the pattern, which being done, the metal is poured.

Mixing and Pouring Metals.—This is yet an open subject. The method commonly adopted for brass is to melt the least volatile metal first, and to plunge the more volatile under the liquid surface with the tongs, in small lumps and hot, in preference to large pieces, which are apt to thicken the copper and cause it to set. We say hot, for the least moisture adhering to cold metal would create danger from being driven off in all directions. We say under the surface, so as to prevent loss from

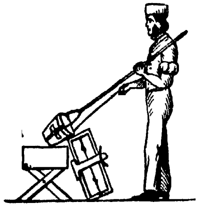

Fig. 16.—Method of Pouring Brass.

its volatile nature. To prevent such loss, charcoal and broken glass have been employed in layers above the metals.

If the metal or alloy be too hot, the casting will

be discoloured or "sand-burned." The best castings are produced when the metal is at such a heat as will cool quickly. The heavy castings take longer to cool, and, consequently, should be poured last. Care must be taken to skim the metal. Fig. 15 shows the method of pouring brass. Small work is poured vertically, large work horizontally.

ALLOYING,

AND THE PROPERTIES OF THE METALS CONSTITUTING THE ALLOYS.

THE metals form part of the elements of nature, are decompounded bodies, and distinguished from the other elements by their lustre, &c.

The *Lustre* is so characteristic as to have formed the common expression "metallic lustre."

Weight is also a rough distinguishing characteristic.

Fusibility is a property common to all metals. Before some metals are rendered fluid by heat, they become pasty; such is an indication of malleability. The following Table gives the degrees (Fahr.) of heat at which metals fuse:—

Tin	442°
Bismuth . .	497°
Lead	612°
Zinc	773°
Antimony . . .	810°
Silver .	1,873°
Copper	1,996°
Gold . . .	2,016°
Iron (Cast) . .	2,786°
Nickel	2,800° (about)
Manganese	3,000° (about)

Malleability, or the property of being beat out into thin plates without cracking or breaking, is common to several metals. The order of malleability is as follows, beginning at the most malleable:—

Silver,	Zinc,
Copper,	Iron,
Tin,	Nickel.
Lead,	

Ductility is also a property found in some metals. It is allied to malleability, and often confounded with it. It is the property of being drawn into wire. The following is the order in which the metals are ductile:—

Iron,	Tin,
Copper,	Lead,
Silver,	Nickel.
Zinc,	

Tenacity, or the resistance to being pulled asunder by the force of tension, varies exceedingly in metals.

The order of tenacity, beginning with the most tenacious, is as follows:—

Iron	549
Copper	302
Silver	137
Zinc	109
Tin	34
Lead	27

Brittleness, resulting from hardness, is a property also met with; and where the brittleness is not extreme, *hardness* is in favour where subjected to the force of compression.

All metals are conductors of heat and electricity, and on becoming liquid evolve heat.

As a general rule, the substances (elements) of nature unite together in fixed and definite atomic proportions, thereby forming new compounds. Metals unite with non-metallic bodies, and obey the same general law; but metals, when united with metals, appear to form an exception, though much doubt exists on the subject. They seem to mix in any proportion, and are thereby modified; possessing thereafter properties which fit them for many purposes in commerce and art. These compounds, being considered at present non-chemical bodies, are classed together under the French term of alloys.

The best known and most serviceable of all the alloys are those composed of copper and zinc, to which have been given the term brass. For most

purposes it is better than copper, being less liable to discolour, harder, closer in grain, more workable, and fusible at a lower degree of heat. It is infinitely better than zinc, being harder, more durable, closer grained, less tarnishable, less brittle, and of better colour.

This alloy is formed by fusing together the two metals, copper and zinc, in a crucible. The copper, requiring 1996° of heat to melt, is fused first, and the zinc, which only requires 773°, is afterwards introduced. If greater heat is used, the metals will vaporise and cause loss. The zinc is introduced immediately before pouring; if allowed to remain long in the furnace, much of it will pass up the chimney. In adding the zinc in mass, care must be taken to have it warm and perfectly free from moisture, to prevent danger.

When the alloy is cast in heavy blocks, it is found that the heavy metal subsides in setting, that a greater proportion of copper is set in the under half of the casting, and thus the composition is redder below, and whiter above, to prevent which some parties have recommended that the casting be fed; but it is not easy to see how feeding will affect the surface of a block, which surface is set before the interior, the interior alone being capable of being fed. The setting in accordance with specific gravity occurs with other alloys. The greater the difference between the specific gravities, the

greater is the difference between the composition of the upper and lower portions of the casting.

There are two properties which are of great value to castings, and which are easily produced in brass. The first is *sharpness*, and is obtainable by the addition of a little lead (from one quarter to two per cent.); the second is *hardness*—bushes, for example, requiring it,—and it is produced by a slight addition of tin (from point nothing to point eight per cent.; thus forming ternary alloys.

The following table of brasses presents at a glance the proportions of the composition, the colour the alloy presents, and the name under which the compound is known:—

BRASSES.—PROPORTIONS AND RESULTS.

Copper.	Zinc.	Colour.	Description.
Wire.	Fumes.	Gold	The gold wire of Lyons.
1 lb.	1 oz.	Red	The jewellers' gilding alloy.
1 ,,	2 ,,	,,	The platin.
1 ,,	3 ,,	,,	Rich sheet-brass.
1 ,,	4 ,,	Deep yellow	Pinchbeck, Bath, similar.
1 ,,	5 ,,	,,	Dutch alloy.
1 ,,	6 ,,	Bright yellow	Bristol sheet.
1 ,,	7 ,,	,,	Good brass wire.
1 ,,	8 ,,	,,	Good ordinary brass.
1 ,,	9 ,,	Full yellow	Muntz's extreme.
1 ,,	10 ,,	,,	Sheathing.
1 ,,	12 ,,	Pale yellow	Spelter solder for copper or iron.
1 ,,	14 ,,	,,	Dipping-brass.
1 ,,	1 lb.	,,	Spelter solder for brass.
1 ,,	2 ,,	Whitish	Watchmakers' brass, crystalline.
1 ,,	8 ,,	,,	Lap-alloy.

The next most serviceable class of alloys is that

composed of copper and tin, to which the terms *bell-metal* and *bronze* are given. Of themselves, these metals are too soft and flexible for most purposes; when united by fusion, the compound is very hard, brittle, and sonorous.

Bronze is of great antiquity. It has been used for weapons, guns, tools, gongs, and bells for time unknown. Tin improves castings of copper. A little zinc, in addition, produces better results. A little brass adds brilliancy to the colour. Lead dulls and destroys it. It is necessary to heat the tin before adding to the copper, as it is apt when cold to produce a lump at the bottom of the crucible.

The particulars of the different bronzes are set forth in the following table:—

SIMPLE BRONZES.—PROPORTIONS AND RESULTS.

Copper.	Tin.	Colour.	Description.
1 lb.	0·5 oz.	Reddish yellow	Ancient nails.
1 "	1· "	"	Soft gun bronze.
1 "	1·3 "	"	For mathematical instruments.
1 "	1·5 "	"	For toothed wheels.
1 "	2· "	Yellow red	Ordnance.
1 "	2·3 "	"	Hard weapon and tool bronze.
1 "	2·5 "	"	" machinery-bearing bronze.
1 "	3· "	Bluish red	Soft, for musical bells.
1 "	3·5 "	"	" gongs.
1 "	4· "	Ash grey	" house-bells.
1 "	4·5 "	"	" larger bells.
1 "	5· "	Dark grey	" the largest bells.
1 "	7· "	Whitish	Ancient mirrors.
1 "	8· "	Whiter	Speculum bronze.
1 "	32· "	Whiter still	Pewterers' temper.

The Japanese, who are great bronze-workers, add lead, zinc, and iron to their bell-metal, with wonderful

effect. Their name for these compounds is *kara kane.* The following are the proportions they use:—

KARA KANE.—(Bell Metal.)

Copper.	Tin.	Zinc.	Lead.	Iron.	Quality.
60	24	9	..	3	First.
60	15	3	8	..	Second.
60	18	6	12	3	Third.

For small bells they employ the first quality, and for large bells the third quality.

There is another kind of bronze, known as Fontainemoreau's Bronze, in which zinc predominates. It is said to answer well for chill moulding, that is, for pouring in metal moulds, by which method it is rendered very homogeneous. The crystalline nature of the zinc is entirely changed by the addition of a small proportion of copper, iron, &c. The alloy is hard, close-grained, and resembles steel. Moreover, it is more fileable than either zinc or copper. The following table presents the proportions in use:—

FONTAINEMOREAU'S BRONZES

Zinc.	Copper.	Cast iron.	Lead.
90	8	1	1
91	8	0	1
92	8	[illegible]	0
92	7	1	0
97	2½	[illegible]	0
97	3	0	0
99½	0	½	0
99	1	0	0

The union of copper with lead is usually termed "pot metal." Lead has the tendency to separate from copper, and cannot be employed in larger proportion than 8 oz. to 1 lb. of copper. Arsenic aids its fusibility. Tin, in small proportion, improves the alloy. The following are the ordinary compounds :—

Lead.	Copper.	Description.
oz.	lb.	
2	1	Red ductile alloy.
4	1	do.
6	1	Dry pot metal, or cock alloy.
7	1	do. but shorter.
8	1	Wet pot metal.

The following table presents some additional compounds for special work :—

Iron.	Brass.	Zinc.	Tin.	Lead.	Copper.	Description.
..	..	..	0·5	1	1	Mortar alloy.
..	..	1	1·6	1 6	1	Socket alloy, Stevenson's.
..	..	0·5	1 5	..	1	Pump metal.
..	..	5	2 5	..	1	Suspending metal.
..	2	..	1·5	..	1	Wheel work.
..	1·5	..	2·3	..	1	Turning work.
0·1	..	0 75	..	..	1	Keir work, forgeable.
0·02	..	0·6	..	..	1	Aich metal, resists sea-water.
00·3	..	0·5	0·02	..	1	Sterro metal, for pumps.

Of the above compounds the keir metal is capable of being made into any shape by the hammer, and is fit for propeller-blades, sheathing, and bolts.

The aich metal is said to be stronger than copper. Sterro metal is said to stand 75,000 lbs. to the square inch.

In using iron filings employ a little corrosive sublimate for fixing it.

Of all the alloys, perhaps no class has occupied more attention than the *white alloys*. First, as a substitute for silver, and secondly, as a source of solder, these compounds have been very successful, and have added very much to the industry of our country. The following table presents the most important:—

TABLE OF WHITE ALLOYS.

Silver.	Nickel.	Brass.	Zinc.	Tin.	Lead.	Copper.	Antimony.	Bismuth.	Description.
	dwts	lb	dwts	lb.	lb.	lb	lb.	lb.	
...	3	...	16			1	..	.	Nickel, or German silver.
...	15	...	13	.	.	1			White copper of China.
...	..	...		9	2		1	2	Queen's metal.
...	..	1	lbs.	49		1	3·5	.	Britannia metal.
...	..	16	2	1	...	...		.	White button metal.
...	...	2	. .	1·5	.	1	..	..	Solder for bell metal.
..	...	1	.	0·6	..	0·15	..		Do. brass.
...	...	...	..	1·	0·5	..	...		Do. tin.
1	...	0·5	...	...	...	...	.		Do. silver.
1	...	0·[illegible]	...	...	...	...	.	.	Do. do.
4	.	..	...	...	..	1	..	..	Do. do.
1	...	0·15	...	...	...	...	...	..	Do. Mokume.
835	...	...	...	...	...	165	...	..	French coin.
950	...	...	50	...	...	...	...	...	M. Piligot's coin alloy.
900	...	...	100	...	...	...	...	...	Do. do.
800	...	...	200	...	...	...	...	...	Do. do.
9[illegible]	...	...	50	...	...	50	...	...	Do. do.
800	...	...	100	...	...	100	...	...	Do. do.
835	..	...	72	...	...	93	.	..	Do. do.
100	...	:	...	...	...	30 to 50	...	..	Gm [illegible]

The substituting of zinc for copper in silver alloys

gives greater fusibility to the alloy. Some small Swiss coins contain zinc in their composition.

Another very interesting alloy has lately come to us from Japan, called *shakdo.* It is composed of copper, with from one to ten per cent. of gold. On being polished it is boiled in a bronze, which we shall describe among the artificial bronzes, presenting a bluish-black colour of great beauty.

There is another interesting alloy being tried in America, but which little concerns the brassfounder being the introduction of a richer metal with iron, which is said to render cast iron doubly strong.

The employment of *arsenic* into alloys requires the use of a good flux to unite it well with the other metals; that flux is commonly *nitre,* or one part nitre and two of tartar. The alloys made with arsenic are chiefly for speculums—that is, telescope mirrors.

TABLE OF SPECULUM ALLOYS.

Silver.	Brass.	Copper.	Tin.	Arsenic.
..	..	32	14	2
..	..	32	13½	1½
..	..	6	2	1
..	..	32	2	1
..	..	3	1¼	
..	..	64	29	
1	1	32	15	

In using arsenic, it must be introduced into the crucible when the mixture is in a melting state

Being in a coarsely-pounded state, it is tied up into a paper bag, and let into the crucible by a pair of tongs. The whole mixture requires to be stirred with a birch rod till vapours cease to rise. Avoid breathing or inhaling while the vapours appear; as soon as they are over the alloy is ready for pouring. Arsenic renders alloys white and hard.

The alloys containing arsenic should be taken out of the flask as soon as properly set, and placed in hot ashes, and in a proper place for protracted annealing.

It is said that speculums are sometimes made from *platina*. It is also on record that platina, plus iron, forms the composition of some Spanish gun-barrels, which never rust, and that iron and copper may be coated with the composition.

LATHE WORK.

The Lathe.—Lathes are almost endless in variety; yet one principle pervades all ordinary lathes, whether propelled by foot or steam. For brass-founders' purposes, the common ordinary lathe, of a somewhat light make, will be found most useful. The following woodcut represents, typically, an ordinary

lathe, the cross or slide bar A B, generally fixed to an iron stand, is made of iron, with its top surface planed. On this bar are fixed the heads and rest. It is of the utmost importance that C D, E F be

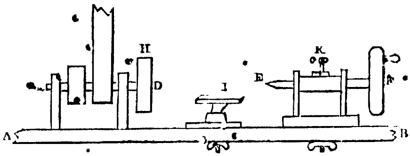

Fig. 16.—Lathe.

in one and the same horizontal line. The chuck H is made to unscrew, so as to allow different sizes and forms of chucks to be used on the same lathe. The chuck-head is always furnished with a loose and fixed pulley, for the shifting of the belt. In the better class of lathes a cone takes the place of the loose and fixed pulleys; in which case a corresponding cone is necessary on the driving or counter shaft. By this means different speeds are attainable, to suit different classes of work. H I K represent the three principal parts of a lathe, viz., the chuck-head, the rest, and the popit-head.

Chucks.—These are screwed to the spindle C D, and are either of iron, lead, or wood. For most purposes, iron chucks are preferred; they are perfectly round, and contain a number of holes for bolts and screws. Chucks are made with sliding plates,

which yield to the tool, for turning ovals and eccentrics. Some of these are very elaborate pieces of workmanship, and produce work of endless beauty. When work cannot be fixed to the chuck by screws, wedges, or spikes, it can be fastened by a cement composed of—

8 parts rosin,
1 part yellow wax,
Brickdust, q. s.

Rests.—These consist of two parts; viz., the socket, with a ground or planed sole for the slide-bar; and the T, to revolve and fix at any angle required. These Ts are constructed of various forms, to meet the various requirements, as shown below.

Point flat.

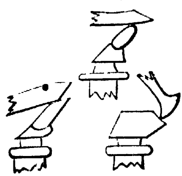

Fig. 17.—Point up. Point down.

For many purposes light slide-rests are superior to the ordinary hand-rest figured above; and as it is generally made self-acting, the work can often be left alone, to execute itself.

The principle of the slide-rest consists in the tool being carried along the work by a screw, which screw can be worked by the motion of the

lathe, and so rendered self-acting. By another screw, the tool is made to approach the work or recede from it at pleasure. Small slide-rests are found most convenient for *fixed-shaped* tools.

Popit or Puppit-head.—These require to be well made, having nicely fitted spindles, heavy fly-wheels, and screws for fixing at top. The soles require to be ground or planed, and have provision —as also the rests—for fixing fast to the slide-bars, such as a screw with large scroll nut.

LATHE TURNING TOOLS—FOR BRASS.

Narrow Tools.—These are used for breaking out, that is, in the first process. A is sometimes made

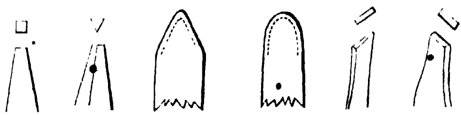

Fig. 18.

from an old square file, and B from a triangular file; C is a pointed tool, a little rounded; D is a gouge breaker; E and F are handed tools.

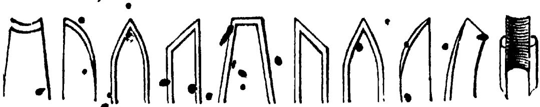
Fig. 19.

Broad Tools.—These are used for finishing.

Where the double line is shown, Fig. 19, the tool

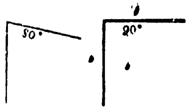

Fig. 20.

is ground to an angle of 80°; where the single line is drawn, the tool remains at 90°. See Fig. 20.

Springing, Planing, and Hollowing Tools.—The springing tool, A, acts as a scraper, to remove all

Fig. 21.

rougliness; and, from the spring which it possesses, the form or shape of the work remains untouched; B is a planing tool for "thin cuts," and leaves the work beautifully smooth; C and D are hook tools, for hollow work.

General Remarks on Lathe Work.—It will be observed that brassfounders' turning tools are of very simple forms, confined generally to round or flat, right or left handed side tools and hooks—all of which resemble very closely the tools for turning hard wood, excepting that the angle is different. The angles we have given above are the finished

angles, that is, when sharpened; they are generally ground to the angles of 60° to 70°.

Should the work, on being chucked, not be perfectly concentric, a narrow tool must be employed to rough it out before resorting to the broad finishing tools; but where a large number of articles of the same kind are to be turned, it can commonly be arranged to have them well formed, clean cast, and truly chucked, in order to avoid waste of time roughing out, and so allow the man to proceed at once with a *fixed* tool to finish the work.

Rings or markings are very apt to appear on the work when broad flat tools are laid close down on the rest, cutting equally keen on the tool's whole surface. Thin goods vibrate and sound like a bell under the circumstance.

To give the tool proper rotation, the tool is somewhat held in the operator's hand, and never allowed to be at rest, the fingers being kept over the rest and under the tool. The tool should not be allowed to incline much, in case of turning the work out into furrows.

Turning about the rest in its socket is, as much as possible, to be avoided. It is commonly retained in a parallel position to the mandril, and face or hollow work turned from an arm-rest running nearly at right angles to the mandril.

Finishing tools are sometimes burnished at the edges, so as to act as burnishers.

In forming the tools for the slide-rest, the roughing-out tools require to be slightly rounded at the advance corner; those intended for finishing are quite sharp. To save the springing of the tool, it should be grasped as near the cutting end as possible.

Turning Tools for other Metals.—Zinc requires the same tools as brass; copper and bronze require the tools used for iron; lead, tin, pewter, and the other soft metals, require the tools employed for soft wood.

Lathe-Boring, Widening, and Countersinking.—These are accomplished by the ordinary drills, wideners, and counter-sinks, introduced into a stock on the chuck. The popit-head, with its boring flange, is moved along by its screw with great exactness. Pulleys and wheels are generally chucked, and a stationary drill thrust through them by the popit-head. Branches for tapered work are usually made five-sided—the angles requiring to be more obtuse than in turning tools, and the velocity of the lathe less in boring than in turning.

All brass-work is wrought dry.

Screws.—There is great diversity in the manner of making screws. Combs are to a greater or less extent in common use. The work is chucked; and, by the aid of an arm-rest, the comb is moved to

and fro, so as to form the thread. The general form of such combs is here shown.

Fig. 22.—Screw Combs.

Traversing mandrils are also in use for making screws. In this case the work moves, and the tool is fixed. Screws are also formed by stocks and dies, and with the screw-plate; but for many purposes the ordinary screwing machines and screw-cutting lathes are found of great service. Screws and spirals may, however, be constructed by an ordinary lathe when a slide-rest, &c., cannot be commanded. The plan is to rule a piece of paper, the pitch of the

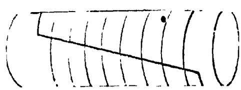

Fig. 23.—Mode of Cutting Screws.

screw or spiral required, and paste it to the rod, as in Fig. 23, chisel the line so formed, and the groove thus formed will guide the turning tool.

The following table gives the number of threads to the inch which is now generally employed in relation to the diameter, and known as Mr. Whitworth's table:—

STANDARD TABLES.

1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	inch diameter.
20	18	16	14	12	11	10	9	8	threads per inch.
1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	..	inch diameter.
7	7	6	6	5	5	4 1/2	4 1/2	..	threads per inch.
2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	5 3/4	4	..	inch diameter.
4	4	3 1/2	3 1/2	3 1/4	3 1/4	3	3	..	threads per inch.

For finer threads, the following may be adopted instead of Mr. Whitworth's:—

1/8	1/4	5/16	3/8	13/32	7/16	1/2	..	.	inch diameter.
36	28	[illegible]	20	20	18	16	..	..	threads per inch.

Screws are sometimes cast, and nuts very frequently cast upon screws.

FILING.

THE file is a tool of very great antiquity. It is cut, by hand or machinery, by percussion, and afterwards tempered. The moist oil, which is on all new files, is apt to collect the filings, and should have sprinkled over it powdered chalk, before using.

The sorts adapted to brass-foundry work are float,

bastard, and smooth files: they are round, half round, square, flat, hand, equalling and rufflers, and vary from 4 to 14 inches. The handles and mountings are sometimes bent, and formed to answer the respective work which they are intended to perform.

Files are only intended to work by advanced strokes, the pressure should be relaxed in withdrawing the strokes; they should not be used sidewards.

The proper position or height at which the work can be best wrought depends upon its size. Small work should be vice-height; mid-sized work should be elbow-height; large work should be from 2 to 3 inches under elbow-height.

Of late years there has been introduced a filing machine for flat surfaces, very much after the motion of a nibbling machine, by which the work is performed with great rapidity. Where a great deal of flat work is done, such a machine is a valuable instrument. The files used for these machines can either be the common file or a very broad file made for the purpose. For flat work, grinding can sometimes take the place of filing.

GRINDING.

The stones used for grinding are varieties of sandstones, commonly from the coal districts, and known as *grit-stones*. They are of a hard, close-grained, yet sharp nature; should be uniform in colour, and free from veins. According to these properties are the stones of different localities suited to the different kinds of grinding work.

These stones are commonly driven by steam power. The velocity, when great, is attended with danger from accidental fracture. It is usual to provide against this by bolting to the sides of the stone iron plates and rings, being careful to interpose felt, canvas, or other soft material between the bolts and the stone.

Wet grinding cuts quickly, and prevents the grain of the stone being choked with particles of metal.

Dry grinding cuts more slowly, leaves a smoother skin, but gives off a considerable amount of dust.

Small stones are moved with treadles or with crank-handle.

EMERY BELTS.

The emery belts are now doing much to take the place of the grindstone. Having an ordinary belt-pulley on the driving shaft of the shop gearing, and another belt-pulley on a stand placed on the floor, the leather belt driving the latter is, before being placed on the pulleys, brushed over on the one side with glue, and, while the glue is yet hot, saturated with emery; the belt, being placed on the pulleys, is now ready for work. The grinder holds the work almost close to the pulley over which he sits. A second belt should always be in readiness to replace the one in use. These belts are found to be more speedy in the execution of work than grinding on stones. A very great amount of filing is saved by resorting to the emery belts. For some purposes emery wheels take the place of belts. These generally consist of a saturated endless band fixed round a wooden wheel, which wheel revolves on its axis in the lathe.

REVOLVING BOX.

A METHOD long used for dressing shot and polishing chains is for some purposes of the brassfounder a great acquisition. It consists essentially of a polygonal-sided iron drum, with an axle passing through the ends. In one of the sides is a sliding door, or grating, to admit or take out the castings. The ends are sometimes grated and sometimes solid. The drum is made to revolve on its axle by means of pulleys and belt from the ordinary shop gearing. The castings are inserted as they come from the dressing shop, the door closed firmly, and the revolution allowed to go on, without attendance, for so many hours, according to the nature of the work. From the grated door, or ends, a considerable amount of brass dust drops into a receiver below, and is afterwards collected. When the work has been duly polished, it will be found that little more requires to be done to it after coming from the revolving drum.

POLISHING.

Brass work is polished by hand labour with emery-cloth and oil. Flat surfaces must be rubbed straight; no curling marks whatever must be seen. Tubes are polished lengthwise. Circular work is polished from edge to centre. The use of cork or wood, in straps, cubes, or balls, for wrapping the emery-cloth upon, is of absolute importance. These straps, cubes, and balls are also employed with baize, for finishing with rotten-stone or whiting, to give greater lustre. Straps, cubes, and balls are also coated with buff-leather for polishing with crocus and oil. Polish is not so much imparted by strength as by light and rapid friction. When the work is not to be lacquered, a minute quantity of oil is allowed to remain on the surface to prevent tarnishing, but the amount must not be so great as to appear oily.

Brass work is also polished by revolving wheels covered with the best hide or old tanned leather. Leather tanned by the modern quick processes absorbs too much oil, and becomes too soft for good polishing leather. The harder the leather, the more glaze is imparted to the work. The leather is soaked in water for a few hours before being glued and tacked down to the wheel, in order that it may contract and become hard on drying. The tacks or nails must be with-

drawn before use. Emery, crocus, &c., are used on these wheels exactly as on straps.

CHASING.

"The art of chasing," says Holtzapffel, "may be considered as the sequel to that of forging"—less the red heat; "but the various hammers and swage tools now dwindle into the most diminutive sizes, and are required of as many shapes as may nearly correspond with the minute detail of the most complex works. Some are grooved and checkered at the ends, and others are polished as carefully as the planishing hammers, that they may impart their own degree of perfection and finish to the work."

MATTING.

This is a process allied to chasing, and most frequently performed on metal patterns. It is simply the indenting of miniature hollows by means of a round-pointed chisel, and making the surface like a file—less the sharp points. Work of this nature requires no finishing on its surface; but on being cast is ready for dipping.

CLOUDING.

THIS process was first introduced by the elder Holtzapffel. It consists of mixing charcoal with water, and pouring on the face of polished brass so as to produce a great variety of circular marks. Slate pencil is employed to fill in portions of the cloud. The work when dry is ready for lacquering.

BURNISHING.

THIS process imparts the highest possible finish to brass or other work. The principle on which this process depends seems to be, that a hard and highly polished substance will, by friction and pressure, impart to another substance its own polish. The softer the substance acted upon, the duller will be the surface.

All work intended to be burnished should be highly finished before the burnisher is applied, or the work will be loaded with furrows.

Burnishers are made from hardened steel, and mostly shaped like a flattened round file. Some are mounted like spokeshaves, with and without foot-straps; others are bent at right angles: some are in the form of hooks; while a few, for long straight surfaces, are attached to a spring-pole from the ceiling.

Burnishers must be kept scrupulously polished between buff-leather sticks with crocus and oil. While in use, they require the application of a lubricous substance, such as sour beer or vinegar water

ANNEALING.

WORK should be annealed before it is dipped. Work which has not been soldered is heated to redness over a charcoal fire, and allowed to cool very slowly, say for two hours. Work which has been hard soldered requires five or six hours' cooling process. Work which is soft soldered requires to be annealed before soldering.

CLEANSING.

THE annealing process cleanses from oil and nearly all impurities, except when the work is afterwards handled. Should further cleansing be necessary, the work is boiled in potash water.

SOLDERING.

FOR the most part, this process is analogous to gluing. The edges of the metals are freed from their coating of oxygen, and united by a more fusible alloy, or metal; thus in

Soft Soldering.—The solder is an alloy of 2 parts of tin to 1 part of lead, fusible at 340°; or, for cheapness, the proportion is sometimes 3 to 2, fusible at 334°. This substance is applied with a hot copper bolt, or by blowpipe flame. Heat, however, would soon cause the edges of the metal again to oxidise; therefore, the edges are covered with a substance having a strong attraction for oxygen, and disposing the metal to unite to the solder at a low temperature. Such substances are called fluxes, and are chiefly

Borax,	Muriate of zinc,
Resin,	Venice turpentine,
Sal-ammonia,	Tallow, or oil.

For brass or other similar alloy, resin, sal-ammoniac, and muriate of zinc are the proper fluxes. Should the work be heavy and thick, the soldering requires to be done over a charcoal fire in order to keep the tool heated within proper limits. The surfaces are as well to be tinned before soldering; in some cases simple dipping into a pot of melted solder effects the purpose, but the dip must be done instantly to be effective.

Zinc, in some hands, is difficult to solder, from the fact that it is apt to withdraw the tin from the soldering bolt, zinc and copper having a stronger affinity for each other than tin and copper. The proper flux is muriate of zinc, made by dissolving small bits of zinc or zinc drops in muriatic acid mixed with an equal bulk of water.

Tin and lead require resin or oil as the flux.

Pewter requires a flux of oil, and may, in addition to the soldering-bolt process, be soldered by a current of heated air.

Britannia metal should have muriate of zinc for a flux, and be soldered by the blowpipe.

Iron requires the surfaces tinned before being soldered.

Soldering per se.—This process is performed by first heating the articles to be soldered, and then pouring on very hot metal till a union is effected. Lead and brass are capable of being united in this way.

TABLE OF SOLDER ALLOYS, AND THE HEAT AT WHICH THEY MELT.

Tin.	Lead.	Melts at
1 part	25 parts	558° Fahr.
1 ,,	10 ,,	541 ,,
1 ,,	5 ,,	511 ,,
1 ,,	3 ,,	482 ,,
1 ,,	2 ,,	441 ,,
1 ,,	1 part	370 ,,
3 parts	2 parts	334 ,,
2 ,,	1 part	340 ,,
3 ,,	1 ,,	356 ,,
4 ,,	1 ,,	365 ,,
5 ,,	1 ,,	378 ,,
6 ,,	1 ,,	381 ,,

TABLE OF BISMUTH SOLDERS.

Tin.	Lead.	Bismuth.	Melts at
4 parts	4 parts	1 part	320° Fahr.
3 ,,	3 ,,	1 ,,	310 ,,
2 ,,	2 ,,	1 ,,	229 ,,
1 part	1 part	1 ,,	254 ,,
2 parts	1 ,,	2 parts	236 ,,
3 ,,	5 parts	3 ,,	202 ,,

Hard Soldering.—The alloy used in hard soldering is made from equal parts of copper and zinc; much of the zinc, however, is lost in the process, so that the real proportion is not equal parts. The alloy is again heated over a charcoal fire, and broken to granulations in an iron mortar. A different proportion is used for soldering copper and iron, viz., three-fourths zinc to one of copper. The commercial name is "spelter-solder."

The flux employed for spelter-solder is borax, which can either be used separately, or mixed, by rubbing, to a cream, or mixed with the solder in a very little water.

When the work is cleaned, bound, fluxed, and speltered, the whole is subjected to a clear charcoal or coke fire; or what is now becoming far more general, convenient, cleanly, and manageable, the bellows blowpipe.

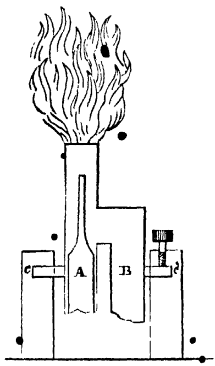

Fig. 24.

The air passes from a bellows propelled by the foot through A, Fig. 24. The gas passes through B, and the flame can be directed to any point, on account of its being hinged at C C. The flame can be extended by using several stands, or by con-

structing several burners on one stand. The heat is much greater than from charcoal, can be regulated at pleasure, and kept at the same temperature for any given time.

In the process of hard soldering, the water should be driven off by gentle heat; the fusion of the flux soon follows; a glassy substance appears after the froth, which, in its turn, is replaced by the alloy in red liquid form; the blue flame from the ignited zinc informs the operator that the solder now fuses, so that as soon as the work is flushed with solder it must be withdrawn, allowed to set, and cooled in water.

The common blowpipe is eminently useful to the brassfounder, and should be mastered early. The cheeks should form the bellows, the wind coming from the mouth, not directly from the lungs.

The composition of the hard solders has been given among alloys; the only other which requires notice is one suited for brazing steel. Its composition is

19 parts silver,
1 part copper,
1 part brass.

Before the metals are placed in the furnace, they should be covered over with charcoal dust.

PICKLING.

When the work is quite free from grease or other impurities, it is left for an hour or two in a glass or earthenware vessel containing

1 part nitric acid,
3 parts water,

and afterwards scoured with a brush quite clear, using fine sand and water. Some work requires to be scoured with pumice-stone and water.

In many cases, and as a matter of economy, the old nitrous acid, diluted with water, from the dipping process, is employed as the pickling liquid.

DIPPING.

When the work is pickled, it is immersed for an instant in pure nitrous acid; a bright surface is at once imparted to the metal or alloy.

On no account must iron or wood be employed in the process of dipping. If nippers are used, they must be of brass.

At times some confusion occurs by using the term "aquafortis" indiscriminately to nitric and nitrous acids

BRONZING.

THIS term takes its origin from the Italian, and was first employed by a school of artists to denote the brown paint upon their statuary. The term has been extended so as to include the chemical stain or deposit applied to metals, for the purpose of imparting to them an antique appearance.

This process has been little developed till within the last few years. Most of the processes have been kept secret, and, consequently, a general dissatisfaction has existed for some time. The want of some standard process, which will produce rapid and certain results, with a choice of tints and colours, is much to be regretted. Should the author have, in an humble measure, mapped the course or pointed to the resources, he shall only have done a duty which was demanded by the times.

Nearly all that has been published on the subject of bronzing—save some variations, and a few receipts unworthy of the paper on which they are printed —is here collected from a variety of sources; but mainly from Messrs. Cooley, Holtzapffel, and Napier, of Britain, and Messrs. Larkin and Overman, of the United States. Most of the published bronzes require days or hours to accomplish their work.

1. Vinegar alone.
2. Aquafortis, dilute.
3. Sal-ammoniac, strong solution.
4. Livers of sulphur, solution.
5. Hydrosulphuret of ammonia.
6. Bichloride of platinum.
7. Sal-ammoniac + vinegar (+ salt).
8. Sal-ammoniac half-pound; nitrous acid, one-third quart; water, two-thirds quart.
9. Sal-ammoniac, one ounce; verdigris, two ounces; vinegar, one pint.
10. Sal-ammoniac, three ounces; salts of sorrel, one ounce; vinegar, one quart.
11. Sal-ammoniac, one part; cream of tartar, three parts; salt, six parts; nitrate of copper, eight parts; hot water, twelve parts.
12. Corrosive sublimate, one ounce; vinegar, one pint.
13. Blacklead, or crocus + water; coat the metal, and burn over a fire.
14. Sulphuret of potassium and water, set in flat dishes, and the metal suspended over it. Effect, same as No. 5.
15. Muriatic acid, six pounds; oxide of iron, two pounds; yellow arsenic, one pound. *N.B.* Immerse; allow to stand moist till quite black, or the colour required; wash; dry in sawdust; and brush with blacklead like a grate.

Since the foregoing was written, the following has appeared in *The Engineer* of February 14, 1868:—

"Although no alloy presents a more agreeable appearance to the eye than brass when it is in a high state of polish, yet the facility with which it tarnishes has rendered it necessary to colour or bronze it, especially in those instances where its use exposes it to the liability of being frequently handled. Many of our readers no doubt remember the

time when all scientific instruments, such as theodolites, levels, circumferenters, sextants, and numerous others of a smaller character, used in the drawing-office, were all manufactured *bright*, as it is termed. At present the best makers universally bronze instruments of the former class, and though they have not absolutely renounced the manufacture in brass of those belonging to the latter, yet they invariably recommend, and justly too, those made of white metal. The reason that it was not until comparatively recently that brass was coloured or lacquered is probably because it takes a layer of colour very badly, and without certain precautions when a coating is laid on, the least shock will suffice to cause it to scale off. Some interesting details have lately been published respecting this very practical subject in a German contemporary, illustrating the methods employed in obtaining a colour of any required tint. An orange tint, inclining to gold, is produced by first polishing the brass, and then plunging it for a few seconds into a neutral solution of crystallised acetate of copper, care being taken that the solution is completely destitute of all free acid, and possesses a warm temperature. Dipped into a bath of copper, the resulting tint is a greyish green, while a beautiful violet is obtained by immersing it for a single instant in a solution of chloride of antimony, and rubbing it with a stick covered with cotton. The

temperature of the brass at the time the operation is in progress has a great influence upon the beauty and delicacy of the tint; in the last instance it should be heated to a degree so as just to be tolerable to the touch. A moire appearance, vastly superior to that usually seen, is produced by boiling the object in a solution of sulphate of copper. According to the proportions observed between the zinc and the copper in the composition of the alloy, so will the tints obtained vary. In many instances it requires the employment of a slight degree of friction, with a resinous or waxy varnish, to bring out the wavy appearance characteristic of moire, which is also singularly enhanced by dropping a few iron nails into the bath. There are two methods of procuring a black lacquer upon the surface of brass. The one, which is that usually employed for optical and scientific instruments, consists in first polishing the object with tripoli, then washing it with a mixture composed of one part of nitrate of tin and two parts of chloride of gold, and after allowing this wash to remain for nearly a quarter of an hour, wiping it off with a linen cloth. An excess of acid increases the intensity of the tint. In the other method, copper turnings are dissolved in nitric acid until the acid is saturated; the objects are immersed in the solution, cleaned, and subsequently heated moderately over a charcoal

fire. This process must be repeated in order to produce a black colour, as the first trial only gives a deep green, and the finishing touch is to polish with olive oil. Much pains are taken abroad to give brass objects 'an English look,' for which purpose they are first heated to redness, and then dipped in a weak solution of sulphuric acid. Afterwards they are immersed in dilute nitric acid, thoroughly washed in water, and dried in sawdust. To effect a uniformity in the colour, they are plunged into a bath consisting of two parts of nitric acid and one part of rain-water, where they are suffered to remain for several minutes. Should the colour not be free from spots and patches, the operations must be repeated until the desired effect is produced."

The Japanese polish their brass, and boil it in a solution composed of—

Sulphate of copper,
Alum, and
rdigris

The following tables exhibit—

THE AUTHOR'S BRONZING LIQUIDS OF 1861.

To be used for BRASS *by simple immersion.*

No.	Water.	Nitrate of Iron.	Perchloride of Iron.	Permuriate of Iron.	Nitrate of Copper.	Tersulphide of Arsenic.	Muriate of Arsenic.	Potash Solution of Sulphur.	Pearlash Solution.	Cyanide of Potassium.	Ferrocyanide of Potassium Sol.	Sulphocyanide of Potassium.	Hyposulphite of Soda.	Nitric Acid.	Oxalic Acid.	
	pt.	dr.	dr.	pt.	oz.	gr.	oz.	dr.	dr.	oz.	pt.	dr.	dr.	dr.	oz.	
1	1	5	...	...	...	...	...	...	...	...	...	...	...	...	...	Brown, and every shade to black.
2	1	...	5	...	...	...	...	...	...	...	...	...	...	...	...	Do. do.
3	1	16	...	...	...	...	...	...	...	...	...	...	16	...	...	Brown, and every shade to red.
4	1	...	...	...	...	...	...	...	...	...	...	...	16	1	...	Do. do.
5	1	...	...	...	1	...	...	...	...	...	...	...	...	...	1	Brownish red
6	...	...	...	...	...	...	...	...	...	...	1	...	...	3	...	Do.
7	1	...	...	...	...	...	...	...	...	1	...	...	...	4	...	Dark brown
8	1	...	...	...	...	30	...	...	6	...	...	...	...	...	...	Yellow to red.
9	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	Orange.
10	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	Olive-green.
11	1	...	5	...	...	...	...	...	...	...	...	2	...	...	...	Slate.
12	1	...	...	...	...	...	...	...	...	...	...	...	20	...	...	Blue.
13	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	Steel-grey.
14	1	...	...	2	...	...	10	...	...	...	...	...	...	...	...	Black.

N.B.—In the preparation of No. 5, the liquid must be brought to boil and cooled.

In using No. 13, the heat of the liquid must not be under 180°.

No. 6 is slow in action, taking an hour to produce good results.

The action of the others is, for the most part, immediate.

THE AUTHOR'S BRONZING LIQUIDS OF 1861.

To be used for COPPER *by simple immersion.*

	Water.	Nitrate of Iron.	Sulphate of Copper.	Sulphide of Antimony.	Sulphur.	Muriate of Arsenic.	Pearlash.	Sulphocyanide of Potassium.	Hyposulphite of Soda.	Hydrochloric Acid.	
No.	pt.	dr.	oz.	dr.	dr.	dr.	oz.	dr.	oz.	dr	
14	1	5	.	...	...	...	...		..		Brown, and every shade to black.
15	1	5	...	...	...	...	..	2	..		Dark-brown drab.
16	1	...	1	...	...	...	.	.	1	2	Do.
17	1	...	.	2	...	...	1	...	.	..	Bright red.
18	1	...	.		1	...	1	..	..		Red, and every shade to black.
19	1	...		...	...	1	...	...	...	.	Steel-grey, at 180°.

FOR ZINC

	Water.	Nitrate of Iron.	Protochloride of Tin.	Sulphate of Copper.	Muriate of Iron.	Muriate of Lead.	Pearlash.	Sulphocyanide of Potassium.	Hyposulphite of Soda.	Garancine Infusion.	Logwood Infusion.	
No.	pt.	dr.	dr.	dr.	dr.	oz.	oz.	dr.	dr.			
20	1	5	...	...	...	...	...	...	...	...	...	Black.
21	1	...	1	...	...	...	...	...	...	...	...	Do.
22	1	...	1	...	...	...	...	1	...	...	...	Dark grey.
23	2	...	...	1	1	...	...	...	...	...	...	Do.
24	...	...	...	...	...	...	...	...	...	...	...	Do.
25	2	...	...	...	1	...	...	...	...	...	...	Green-grey.
26	...	...	...	...	..	...	...	...	...	×	...	Red—Boil.
27	1	...	...	4	...	...	[illegible]	...	..	...	...	Copper colour. Plates so [illegible].
28	1	[illegible]	...	8	...	...	[illegible]	...	8	...	...	Copper colour, with agitation.
29	...	...	...	...	...	...	...	...	...	...	×	Purple—Boil.

× Made to the consistency of cream.

Mr. Larkin stated in 1866 that, "for the purpose of rendering the alloys, which are of a silvery-grey colour, perfectly suitable as substitutes for copper, bronze, brass, and other metals, the colour proper to the metals of which they are intended to be substitutes is imparted to them by means of any solution of copper. The hydrochlorate of copper is found to answer best.

"Firstly. For giving the alloys a blackish-bronze colour, they are treated with a solution of the salt of copper diluted with a considerable quantity of water, and a small quantity of nitric acid may be added.

"Secondly. To impart a lead or copper colour, add to the solution of the salt of copper liquid ammonia and a little acetic acid. The salt of copper may be dissolved in the liquid ammonia.

"Thirdly. To impart a brass or antique bronze colour, either of the three following means may be adopted :—

"1st. A solution of copper, with some acetic acid.

"2nd. The means before described for copper colour with a large proportion of liquid ammonia.

"3rd. Water acidulated with nitric acid, by which beautiful bluish shades may be produced. It must be observed, however, this last process can only be properly employed on the alloys which contain a portion of copper.

"In either of these methods of colouring, a solution

of sal-ammoniac may be substituted for the liquid ammonia. The quantities of each ingredient have not been stated, as these depend upon the nature of the alloy, the shade or hue desired, and the durability required.

"The bluish-bronze colour may be superadded to the red or copper colour, whereby a beautiful light colour is produced on the prominent parts of the article bronzed, or on the parts from which the blackish-bronze colour may have been rubbed off.

"These new alloys may be used as substitutes for various metals now in general use, such as iron, lead, tin, or copper, in pipes and tubes; and bronze, brass, and copper, in machinery and manufactories, as well as for most of the other purposes for which more expensive metals are employed."

Brass obtains a very beautiful drab-bronze by being worked in moulders' damp sand for a short time and brushed up.

LACQUERING.

THIS process is simply varnishing for the purpose of protecting the colour of the metal, and should be applied within an hour after dipping or bronzing.

The lacquer, like all other varnish, consists of a

solution of gum or resin; and when coloured, it is so by the introduction of other substances, usually another gum or resin.

The Materials.—These substances should be kept in separate and well-labelled bottles, both in a dry state (excepting liquids) and in solution, so that at any moment a required tint may be produced. Beneath, we give a list of the materials; their nature and properties will be found in their proper place.

The lacquer = Shellac + spirits of wine.

Other substances . . .	Turpentine, spirits of. " varnish. Mastic varnish. Canada balsam.
B . . .	Pyro-acetic ether.
C = red . .	Dragon's blood. Annotta. Red saunders.
D = yellow	Turmeric. Gamboge. Saffron. Sandarac. Cape aloes.

The Effects of Light and Heat on Lacquers.—Throughout the whole of nature, light and heat produce wonderful effects. Some substances will remain as long as wished in the dark, but will change and explode when brought to the light. Lacquers, after a like order, change in the light, and become dark in colour; while heat, from whatever source, sets up evaporation and continual change. There is

a common practice of keeping lacquers in black bottles, to prevent the action of light; but the lacquer might as well be in clear white glass bottles, as the only colour through which the chemical rays of light will not pass is yellow. Therefore, the only bottles in which lacquers can be kept free from its action are made of yellow glass or stone-ware.

Lacquer Dishes and Brushes.—Besides the above-mentioned bottles, there are required flat dishes, with cross rods and camel-hair brushes. These dishes should be made of plate glass, cemented with marine glue; the plate glass drilled, and a glass rod inserted at the proper place, and also fixed with marine glue. The brushes must have no tinned-plate fastenings.

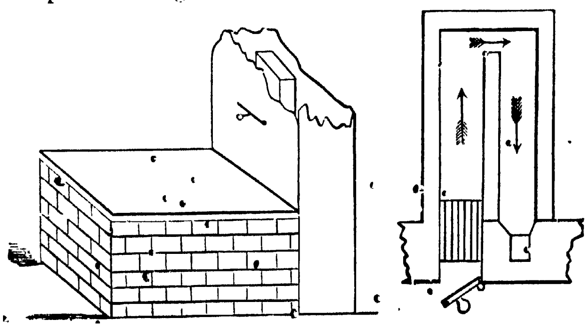

Fig. 25.

Lacquer Room and Stove.—It is usual to set apart a room for the purpose of lacquering, to be perfectly

free from dust, and yet adjacent to the finishing-shop. This room is furnished with a hot-plate stove, with the coking-door and ashpit outside of the room. The ordinary construction is that of the foregoing figure, where the vent passes up the wall which divides the finishing-shop from the lacquering-room.

The flue passes to the front of the stove, and then returns to the wall.

It is sometimes better to do away with the ordinary stove, and substitute a steam chest in the centre of the room. The steam chest need not be deep—usually about four inches—set on legs the height of a table. The other sizes will depend upon the amount of work sent through the lacquer-room.

An iron canopy, hung with weights on pulleys, surmounts the stove or steam chest in order to confine the heat. A few old dish-covers for the same purpose, for small articles, will be found of service.

The work should be heated to the degree of boiling water, so as to drive off all cold and moisture, and cause the evaporation of the spirits in the lacquer. When the work is too hot, it oxidizes.

The following table gives in detail the proportions of the various substances employed in the manufacture of lacquers; the broad principles by which colour is given to them will be apparent at a glance, and require no explanation

TABLE OF LACQUERS.

				SOLUTIONS.					REDS.			YELLOWS.					
	Shellac.	Mastic.	Canada Balsam.	Spirits of Wine.	Pyro-acetic Ether.	Spirits of Turpentine.	Turpentine Varnish.	Simple Pale Lacquer.	Dragon's Blood.	Anotta.	Saunders.	Turmeric.	Gamboge.	Saffron.	Cape Aloes.	Sandarac.	
No.	oz.	dr.	dr.	pt.	oz.	dr.	oz.	pt.	dr.	dr.	gr.	dr.	dr.	dr.	dr.	dr.	
1	4	...	..	1		...								..	...		Strong simple.
2	1			1		..								..	...	..	Simple pale.
3	1			1			..	..					1	..	3	..	Fine pale.
4	1	...		1								1	1	2	...		Do.
5	1	...	...	2					1	1		...	16	4	...	8	Do.
6	2	...	...	2					1	8		32	...	...	...	8	Pale gold
7	2	..		1								...	2	...	4		Pale yellow.
8	5			3	30		..					...		...	...	..	Do. Ross's
9	...			..	..	..	...	1		1	..	4		..	..	...	Full yellow.
10	3	...		1	..		...	...	...	2		16		2	...	..	Gold.
11	3	..	..	4	...	..	6	...	...			64	6	...	...	14	Do.
12	1	..	..	1	..	...	...	...	..	..		20	...	...	2	5	Do.
13	3	...	...	1	..		...	...	4	...		16	...	...	...	..	Deep gold.
14	3	..	...	1	..	..	...	...	4	..		1	...	...	...		Do.
15	3	...	...	1	..	30	...	...	40	..	12	10	...	...	...	...	Do.
16	...	...	...	...	...	...	...	1	8	32	...	...	...	...	...		Red.
17	1	...	...	...	...	..	1	...	8	21	...	...	...	...	...	27	Do.
18	15	30	30	6	...	...	...	...	20	...	...	60	...	10	...	...	Tin lacquer.
19	...	...	...	...	...	...	..	1	...	...	...	4	1	...	...	...	Green, for bronze.

N.B.—The union of red with yellow produces a fine orange colour.

CHEMICAL ANALYSIS OF PRECEDING METALS AND ALLOYS.

To Dissolve.—The metals and alloys are soluble in certain acids—most of them require a little time: the finer they are reduced before being added to the acids, the sooner will the solution be complete.

Copper, zinc, bismuth, and nickel are soluble in nitric acid.
Lead and antimony are soluble in one part nitric acid with two parts hot water.
Tin is soluble in hydrochloric acid.

To Precipitate:—

Copper, tin, lead, bismuth, and antimony, when in acid solution, are precipitated when there is introduced into the solution sulphuretted hydrogen gas.
Zinc and nickel are precipitated by hydro-sulphuret of ammonia.

When a precipitate is formed in any solution, a chemical union has taken place—two substances have united on account of the strong affinity they have for one another; they unite, not as an irregular mass, but in definite atomic proportions or fixed amounts. In the preceding precipitates, the sulphur of the precipitate unites to the metal and forms a chemical substance known as a SULPHIDE of the METAL.

Reduction to Relative Weights.—For the most part, these sulphides are composed of one grain or atom of sulphur with one grain or atom of the metal, except in the case of bismuth and antimony, where two grains of sulphur unite with one grain of the metal. By using the word grain, we do not mean a grain weight, but the smallest conceivable quantity or atom. Now, to find the weight of this atom, which no one has ever seen, a cubic inch of the lightest known substance, hydrogen gas, is taken, and a cubic inch of sulphur, and we find that it takes sixteen of the cubic inches of hydrogen to poise the one cubic inch of

sulphur; so we say, the weight of sulphur is 16, and by the same process we find the weight of the metals to be—

Copper	31·7
Zinc	32·6
Tin	58·
Lead	103·7
Nickel	29·6
Antimony	129·
Bismuth	213·

To Separate and Determine.—When it is the simple analysis of only one metal which is sought for, and that metal known, the dried sulphide precipitate contains 16 parts of sulphur to the number of parts placed opposite the name of the metal in the above list, except in the cases of bismuth and antimony, when the equivalent or weight for sulphur is 32.

When, however, the object treated is complex, separation must take place.

Tin is not soluble in nitric acid, and will remain behind as a binoxide of tin; every 74 grains of which contain 58 grains of pure tin.

If lead is present, it is precipitated by sulphuric acid as a sulphate; every 152 grains of which contain 104 grains of pure lead.

When copper is present, it is precipitated by sulphuretted hydrogen, washed with potash to dissolve the antimony or arsenic if present; every 48 parts of which contain 32 parts of copper.

If zinc is present, precipitation is formed by carbonate of soda, and boiled; every 40 parts contain 32 parts of zinc.

When it is wished simply to know what metal is present, the most convenient mode is to pound a grain weight of the substance under examination with about 100 grains of borax or other salt, and subject it to the blowpipe. See Plattner's, Mitchell's, or Elderhost's works for instructions on Blowpipe Analysis; also the respective metals, at page 80.

CLASSIFIED LIST OF MOST SUBSTANCES USED BY BRASSFOUNDERS.

MINERALS.

Black-lead.—Obtained from Cumberland, where it exists in a bed of trap-rock, alternating with clay-slate. It contains no lead, but is carbon; the same substance, chemically, as the diamond, except in a different condition, and containing a small proportion of iron, in which state it has been termed a non-cohesive alloy. Commercial black-lead is

often adulterated to the extent of from 30 to 70 per cent.

Chalk.—Obtained from the white cliffs along the south-east coast of England. It is an earthy carbonate of lime. When scraped down, it makes a better polishing substance than the prepared chalk known as whiting.

Crocus.—Obtained by calcining green vitriol, *sulphate of iron*, roasting, and washing. It is also prepared by precipitation with carbonate of soda. In this state it is very fine. It forms a sesquioxide of iron, soluble in acids.

Emery.—Obtained from the islands of the Grecian Archipelago, where it is found at the foot of the primitive mountains. It is a granular variety of corundum or adamantine spar. It ranks next to the diamond in hardness.

Plaster of Paris.—Obtained from gypsum by decomposition; it should be heated to dryness before being mixed, and used with as little water as possible. It is much adulterated.

Pumice-stone.—Obtained from Campo Bianco, one of the islands of Lipari. It is the green glassy felspar melted by volcanic fire, and acted on by gases or watery vapours, and ejected as a whitish, spongy, porous substance. (See Professor Silliman's "Visit to Europe in 1851," vol. ii. p. 4.

Sulphur.—In its crude state it is known as brim-

stone. It is an element of nature, soluble in hot potash, melts at 218°, and is volatile above 300°; burns with a blue flame, and leaves no residue. It is obtained from the sulphides of iron, lead, and copper; in a purer state from Sicily, where it is found imbedded in blue clay. It is emitted from volcanoes, although to no great extent, in the form of sulphurous-acid vapours, which crystallize into beautiful needle-shaped crystals, crossing and entangling with one another in brilliant and endless confusion. The connection between sulphur and volcanoes may be so expressed. Heat comes from the sun, and therewith electricity; the earth is charged with it according to the conducting or non-conducting nature of the soil; when the electric current is retarded by a bad conductor, such as sulphur, soil heat is evolved; hence arise volcanoes in sulphurous countries. In like manner thunder-storms are simply valves for the escape of forces which would tear up the world by earthquakes.

Sulphur makes an excellent flux in the manufacture of brazing solder. It makes excellent casts, and is extensively used as a substitute for bat-lead.

Rotten-stone.—The sort commonly employed in this country is, according to Holtzapffel, peculiar to England, and is found in large quantities both in Derbyshire and South Wales. It is also obtained from Tripoli, in Asia Minor; and is much used, under

the name of *Tripoli*, all over the world. It is found in small patches in some of the western islands of Scotland; and furnishes beautiful specimens of the shells of the decayed plants for the microscope. This substance was formerly believed to be animal infusoria, and has been much studied of late, under the name of *Diatomaceæ*.

Sands.—Brassfounders' sands are obtained principally from Hampstead or Belfast. They contain about 94 per cent. of silex. Their properties have been already described.

Whiting.—Ground and washed chalk. Its particles are very fine, and hardly able to abrade. Its principal object is to absorb the oil or grease from the work previously polished by other means, and to impart a finishing gloss.

METALS.

Copper.—Obtained from Cornwall, in England, by calcining and roasting the ore, which yields 8 per cent. or so of metal: we raise about 15,000 tons per annum. About ten times as much is imported from Chili, Cuba, United States, Australia, and South Africa. About 30,000 tons per annum are usually exported from this country to British India, France, Egypt, and Holland.

Damp air, acid vapours, ammoniacal liquids, and gases produce green salts upon the surface of copper;

it is also acted on by a weak solution of common salt, while it is not acted upon at all by a strong solution.

Copper is precipitated from solutions by sulphuretted hydrogen gas, giving a black deposit. It is also precipitated by potash, soda, carbonate of soda, and ammonia, yielding blue or bluish-green deposits. Ferro-cyanide of potassium gives a reddish-brown precipitate. In mass, copper and its alloys impart a green colour to the outer flame of the blowpipe when it is exposed to the inner flame.

Lead.—Obtained from Derbyshire, in the form of sulphide and slickenside ores. The term "slickenside" arises from the loose nature of the rock, which, on being struck, comes tumbling down for hours, while a series of violent and dangerous explosions is set up, and the ore is left broken to the miner's hand.

About 70,000 tons are raised annually in this country. About half that quantity is imported chiefly from Spain and Sardinia. We export about 20,000 tons to the United States, France, and China.

The atmosphere produces on lead a coating of carbonate of lead. Pure water absorbs a portion of lead, and forms a poison. Lead is precipitated from solutions by sulphuretted hydrogen gas, producing a black deposit; it is also precipitated by potash, carbonate of soda, and ammonia, yielding a white precipitate. Chromate of potash gives rise to a yellow

deposit; in mass it produces a yellow oxide on charcoal before the blowpipe.

Tin.—Obtained from Cornwall, from the oxide, intermixed with quartz. The ore is blackish, but white when pounded; it is obtained in large pieces, being blasted by gunpowder. In the pounded state it is smelted and again refined. Though the ores are much mixed up with other metals, as arsenic, tin, zinc, copper, &c., yet they yield at times 70 per cent. of pure tin. We raise about 10,000 tons a year, and import about half that quantity, chiefly from British India; while we export about 7,000 tons to France and the United States.

Air and water have little effect on tin; acids produce rapid oxidation, and at the melting point it is converted into putty powder. A black precipitate occurs with sulphuretted hydrogen; a purple with terchloride of gold.

In mass, with equal parts of carbonate of soda and cyanide of potassium, as flux, metallic tin is produced by the inner flame of the blowpipe.

Zinc or Spelter.—Obtained chiefly from Hamburg, Prussia, Belgium, and Holland. The ores are mostly carbonates and silicates, and are reduced by calcining and smelting. Zinc is very impure, being imperfectly reduced; there remaining much arsenic and iron.

We import about 35,000 tons per annum, and obtain from British mines about 4,000 tons. The

exports amount to about 8,000 tons to British India and France.

Exposed to the air, zinc becomes grey from a coating by oxygen. It is brittle when cold; ductile at 212° to 300°; brittle again at 450°; fuses at 770°; while at 940° it is converted into flowers of zinc.

Potash, soda, and ammonia produce a white precipitate, soluble in excess of the precipitant.

In mass, moistened with cobalt, it produces a beautiful green before the blowpipe.

BASES AND SALTS.

As a general rule, bases are oxides of metals and salts are bases in union with acids.

Arsenic.—The arsenic of the shops is an oxide of the metal arsenic. It has acid properties, and receives the additional name of *arsenious acid.*

Bichloride of Platinum.—This is the metal platinum in union with two atoms of chlorine.

Borax.—This is the bi-borate of soda. It has a strong attraction for oxygen when heat is applied. Used as a flux, it frees the metal from its oxide, and allows the solder to have complete union with the metal.

Chloride of Zinc, also known as *Muriate of Zinc.*—This is formed when sheet zinc is dissolved in hydrochloric acid, filtered, and crystallized. It is caustic, and used as a flux.

Cream of Tartar.—The bitartrate of potash. This is used to dispose one metal to adhere to another.

Cyanide of Potassium.—The yellow prussiate of potash heated with the dry carbonate.

Ferrocyanide of Potassium.—The result of uniting potash with iron turnings and refuse animal matter. It is the yellow prussiate of potash.

Hyposulphite of Soda.—This is soda, plus hyposulphurous acid. It is soluble to a very large extent in water.

Muriate of Tin.—One ounce of powdered tin is dissolved in four ounces of concentrated muriatic acid by means of heat, and when cold is diluted with an equal bulk of water. This substance is used to tin iron and steel. The iron is dipped into the solution, and by its side a plate of clean copper; a voltaic current is set up, and tin is deposited on the iron.

Nitrate of Copper.—This is copper, plus nitric acid; crystallizes blue; soluble in water, and readily parts with its copper.

Nitrate of Iron.—This is iron dissolved in nitric acid to a syrup.

Perchloride of Iron.—This is rust, or oxide of iron, dissolved in hydrochloric acid. Crystallizes red; soluble in water; very corrosive.

Peroxide of Iron, Hydrated.—This is the precipitate which is formed on the addition of potash or ammonia to a solution of sesquioxide of iron.

Potash is a crude carbonate of the hydrated oxide of potassium, and is obtained from America and Russia. It is also manufactured at home from the sulphate by roasting. It is a strong alkali.

Protochloride of Tin.—This is an excess of tin digested in hot hydrochloric acid. Its crystals are like needles. It is a deoxidizing agent.

Sal-Ammoniac.—This is hydrochlorate of ammonia. Can be made either from gas-liquor or bone-liquor.

Soda.—A carbonate of sodium obtained from sea-salt. It is a strong alkali, and, like potash, unites with oil, grease, or fatty matter, and is converted into soap.

Stannate of Potash.—This is potash with stannic acid, which acid is a product of potash and perchloride of tin. It is used for tinning in the same manner as cream of tartar.

Sulphide of Antimony.—This is simply sulphur, plus antimony. In itself it has little action; with potash, it deposits red on copper; with acids, its action is frequently apparent.

Sulphocyanide of Potassium.—This is made by digesting 3 parts of cyanide of potassium with 1 part of sulphur and 6 parts of water. The crystals are white, deliquescent, soluble in water, and unite with the persalts of iron.

Tersulphide of Arsenic.—This is formed by sub-

limation of arsenious acid with sulphur. It is also found native. Those formed by nature are yellow and red, and may be produced by the receipt in the table of bronzes for brass.

White-lead.—This is subcarbonate of lead, and is produced whenever sheet-lead is acted on by vinegar. Commercial white-lead contains contaminations of baryta, and sometimes chalk.

GUMS, RESINS, AND COLOURING SUBSTANCES.

Annotta.—Obtained from the seed of the *Bixa Orellana* of South America. It contains

28 per cent. of resin, and
20 per cent. of colouring matter.

It has the colour of flame, and possesses a strong smell.

With pearlash the colour of annotta may be regulated in solution; precipitated thereafter with oil of vitriol, diluted with 20 parts of water, and dried.

Cape Aloes.—Obtained from the aloe of the Cape of Good Hope. It contains a gum and a resin in mechanical mixture. In mass it is greenish brown; in powder it is a greenish yellow; soluble to a large extent in boiling water.

Dragon's Blood.—Obtained from various species of the genus *Calamus*, principally from *Dracæna draco*,

or dragon-tree. One of these trees growing at Oratava, in Teneriffe, is said to be 6,000 years old at present. This plant is of very slow growth. The resin is of a red colour, in lump dark, in powder bright, and yields transparent solutions soluble in ether and alcohol. It is much adulterated. A factitious article is made from shellac, Canada balsam, gum benzoin, sanders wood, and Venetian red.

Gamboge.—Obtained from the *Gracinia*. It is brought from Siam, is yellow, and soluble in ether and alcohol.

Gum Arabic.—Obtained from the acacia-tree of Arabia, &c. Well known.

Gum British.—Chiefly used for giving adhesion to the sand for making cores; is obtained by exposing dry potato starch to calcination in a stove heated to 400° Fahr.

Lac.—Obtained as a concrete juice upon the branches of the *Ficus Indica*, &c., and is produced by the puncture of an insect. Lac should be obtained as pale as possible; when required white, it can be bleached by passing a current of chlorine gas through it, or by boiling the solution for a few minutes with animal charcoal, filtering through silk and then paper.

Resin.—An after-product in the making of turpentine. According to Liebig, all resins are oxidized essential oils. It is soluble in alcohol.

Saffron.—Obtained from the pistils of the saffron crocus. It contains a polychromatic principle.

With alcohol it gives a gold-yellow colour;
With sulphuric acid, a lilac colour;
With nitric acid, a green colour.

Sandarac.—Obtained from the juniper-tree of Africa; it has a slight smell; it easily dissolves.

Turmeric.—Obtained from the *Curcuma longa* root of Ceylon. It imparts brown to alkalies, and red to acids.

SOLVENTS, ACIDS, AND OILS.

Spirits of Wine, or Alcohol.—This is derived from malt. It is combustible, pungent to taste, and has a penetrating odour. It can be purchased free from duty, under the name of methylated spirits, and rectified as follows:—

To every pint add four ounces perfectly dry pearl-ash; shake the bottle occasionally for several days, decant the clear liquid, and distil from a flask through a Liebig condenser. The product should yield 90 per cent. real alcohol.

Water is detected in spirits of wine by sulphate of copper; wood spirits, by potash. Under the name "Finish," alcohol is sold containing some resinous matter.

Pyroacetic Ether, or Acetone.—This is made by the dry distillation of acetate of baryta in a shallow

retort, and at as low a heat as consistent with its decomposition. The oil is separated from the product, and the latter rectified over quicklime, mixed with a little animal charcoal. The process is repeated till the boiling point is constant, and the acetone pure.

Sulphuric Acid.—Oil of vitriol, a compound of sulphur and oxygen. Well known.

Nitric Acid.—Aquafortis, a compound of nitrogen with oxygen in the proportion of 1 to 5.

Nitrous Acid.—The peroxide of nitrogen, having the proportion of 1 of nitrogen to 3 of oxygen.

Hydrochloric Acid.—Marine acid, or spirits of salt, a compound of equal proportions of hydrogen and chlorine.

Sulphuretted Hydrogen.—Equal parts of sulphur and hydrogen. A highly poisonous gas.

Sweet Oil.—Formerly obtained from the wild or rape turnip, but now from the seeds of the *Brassica napus.*

Sperm Oil.—Obtained from the head of the spermaceti whale. Does not thicken by age or friction.

The quality of oils is known from the amount of soapy cream which arises when mixed with pearlash.

SAWDUSTS.

Sawdust.—It is best obtained from boxwood, because it contains no resinous substance. The next best is from beechwood.

ON THE RECOVERY OF BRASS FROM THE ASHES AND SWEEPINGS OF THE FOUNDRY.

THE ashes and sweepings are generally sold, the brassfounder not troubling himself with details of recovery.

In the case of sweepings, they are put into a tub with about four times their bulk of water and washed; the dust rises to the top, and after the metal settles to the bottom, the bulk of the water is poured off. This process is repeated till the water is pretty clean. The metal is allowed to dry, then put into a close crucible and melted. It is usually run into ingots.

More care is required with the ashes: the best smelters grind them before washing, and then proceed as above. The metal obtained from the ashes is generally rich in copper, and it is usual to add some zinc, in order to reduce the quality.

Care must be taken to prevent fine particles being washed away.

ON THE RECOVERY OF COPPER FROM THE DIPPING LIQUIDS.

It must be evident to those who have read the foregoing pages that, in the process of dipping brass, part of the ingredients must be dissolved in liquids.

The best method of recovering the loss is by evaporating the liquids to a considerable extent, and introducing zinc drops in order that they may be covered over with copper, in which state they are melted in the usual manner.

ON THE USE OF SALT-CAKE.

In smelting expensive metals, the use of a little salt-cake as a flux greatly improves the appearance of the metal or alloy, the refuse uniting with the salt-cake to the surface of the crucible, and is skimmed off.

WEIGHT OF BRASS.

There already exists a table of weights for cast brass per square foot, which has been published in several books. The author has had considerable difficulty in attempting to reconcile published with actual weights, on account, no doubt, of the different proportions of copper and zinc used in its manufacture. This will be found at all times a difficulty with alloys.

The following tables, however, are calculated from actual and repeated weighings at cardinal points, and are adapted to the present state of the trade.

The tables on sheet brass per wire gauge, brass tubings, bar brass, and brass wire, &c., will, the author trusts, be found of considerable advantage.

The first two tables are drawn out in a peculiar skeleton-like form, in order that attention may be directed to a sort of ratio which exists, especially in sheet brass per wire gauge, and at the same time to assist the memory in recollecting those sizes which have even weights.

TABLES OF WEIGHTS.

SHEET BRASS—BIRMINGHAM WIRE GAUGE.

No.	Decimal of 1 inch.	1 × 1.	2 × 1.	3 × 1.	4 × 1.	5 × 1.	6 × 1.	7 × 1.	8 × 1.	9 × 1.	10 × 1.	11 × 1.	12 × 1.	12 × 12.	
W.G.		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	lb.	oz.
1	·300	1½	3	4½	6	7½	9	10½	12	13½	15	16½	18	13	8
2	·284	..	..	..	..	..	8⅗	..	..	..	..	..	16¾	12	9¼
3	·259	..	..	..	..	..	7¾	..	..	..	..	..	15½	11	10½
4	·238	..	..	..	..	..	7⅕	..	..	..	..	..	14¼	10	12
5	·220	..	..	..	..	..	6½	..	..	..	..	..	13	9	14½
6	·203	1	2	3	4	5	6	7	8	9	10	11	12	9	2
7	·180	..	..	..	..	..	5½	..	..	..	..	..	11	8	1½
8	·165	..	..	..	..	..	5	..	..	..	..	..	10	7	7
9	·148	¾	1½	2¼	3	3¾	4½	5¼	6	6¾	7½	8¼	9	6	10¾
10	·134	..	..	..	..	..	4	..	..	..	..	..	8	6	0
11	·130	..	..	..	..	..	3¾	..	..	..	..	..	7⅙	5	6½
12	·109	..	..	..	..	..	3½	..	..	..	..	..	6⅔	5	0¼
13	·095	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	4	6
14	·083	..	..	..	..	..	2½	..	..	..	..	..	5	3	11¾
15	·072	..	..	..	..	..	2¼	..	..	..	..	..	4⅓	3	4
16	·065	..	..	..	..	..	2	..	..	..	..	..	4	2	15
17	·058	..	..	..	..	..	1¾	..	..	..	..	..	3½	2	9¾
18	·049	¼	½	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	2	4
19	·042	..	..	..	..	..	1⅓	..	..	..	..	..	2 6/12	1	14
20	·035	..	..	..	..	..	1⅙	..	..	..	..	..	2 1/12	1	9
21	·032	..	..	..	..	..	1	..	..	..	..	..	2	1	7
22	·028	..	..	..	..	..	⅞	..	..	..	..	..	1¾	1	4½
23	·025	⅛	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1	2
24	·022	..	..	..	..	..	4/6	..	..	..	..	..	1⅓	1	0
25	·020	..	..	..	..	..	7/12	..	..	..	..	..	1⅕	0	14½
26	·018	..	..	..	..	..	13/24	..	..	..	..	..	1 1/12	0	13

CAST BRASS—MEASURED BY INCHES.

W.G.		1 × 1.	2 × 1.		3 × 1.		4 × 1.		5 × 1.		6 × 1.		7 × 1.		8 × 1.		9 × 1.		10 × 1.		11 × 1.		12 × 1.	
No.	in.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
16	1/16	..	..		..		..		..		0	1⅞	..		..		..		..		..		0	3¾
11	⅛	..	..		..		..		..		0	3¾	..		..		..		..		..		0	7½
..	3/16	1	0	2	0	3	0	4	0	5	0	5½	0	6	0	7	0	8	0	10	0	10	0	11
3	¼	..	..		..		..		..		0	7½	..		..		..		..		..		0	15
..	5/16	1½	0	3	0	4½	0	6	0	7½	0	9	0	10½	0	12	0	13½	0	15	1	0½	1	2
..	⅜	2	0	4	0	6	0	8	0	10	0	11	0	12	0	14	0	16	0	18	0	20	1	6
..	7/16	..	..		..		..		..		0	13	..		..		..		..		..		1	10
..	½	..	..		..		..		..		0	14¾	..		..		..		..		..		1	13½
..	9/16	..	..		..		..		..		1	1	..		..		..		..		..		2	2
..	⅝	3	0	6	0	9	0	12	0	15	1	2	1	5	1	8	1	14	1	14	2	1	2	4
..	11/16	..	..		..		..		..		1	4¼	..		..		..		..		..		2	8½
..	¾	..	..		..		..		..		1	6	..		..		..		..		..		2	12
..	13/16	4	0	8	0	12	1	0	1	4	1	8	1	12	2	0	2	4	2	8	2	12	2	15½
..	⅞	..	..		..		..		..		1	9½	..		..		..		..		..		3	3
..	15/16	..	..		..		..		..		1	11½	..		..		..		..		..		3	7
..	1	..	..		..		..		..		1	13¼	..		..		..		..		..		3	10½
..	1⅛	..	..		..		..		..		2	0¾	..		..		..		..		..		4	1½
..	1¼	6	0	12	1	2	1	8	1	14	2	4	2	10	3	0	3	6	3	12	4	2	4	8
..	1⅜	..	..		..		..		..		2	8	..		..		..		..		..		5	0½
..	1½	..	..		..		..		..		2	12	..		..		..		..		..		5	7⅔
..	1⅝	..	..		..		..		..		2	15¼	..		..		..		..		..		5	14½
..	1¾	..	..		..		..		..		3	3 1/12	..		..		..		..		..		6	6⅛
..	1⅞	9	1	2	1	11	2	4	2	13	3	6	4	0	4	9	5	2	5	11	6	4	6	12
..	2	..	..		..		..		..		3	10½	..		..		..		..		..		7	5

[illegible] Rods, One Foot Long.

1/4	3/8	1/2	5/8	3/4	7/8	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3¾	4
lb.	lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·17	·39	·7	1·1	1·59	2·16	2·83	4·42	6·36	8·66	11·32	14·32	17·68	21·4	25 5	30·2	44·6	50·3	58·3

Brass Wire, 10 Yards Long, by Wire Gauge Nos.

Nos. 1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
7·59	6·59	5·59	4·81	4·0	3·31	2·81	2·4	2·0	1·59	1·0	·59	·4	·24	·14	0·8	0·5

Plain Brass Tube, One Foot Long.

1/4	5/16	3/8	7/17	1/2	9/16	3/4	5/8	1½	1¼	1	7/8	1¾	2	2½	3
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
·08	·15	·19	·21	·25	·31	·43	·37	1·0	·81	·59	·50	1·12	1·25	1·50	1·87

Spiral Brass Tube, One Foot Long.

3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1¼	1½
oz.	oz.	oz	oz.	oz.	oz.	oz.	oz.	oz.	oz.
3	3¼	3¾	4½	5	[illegible]	7¼	9	12	15

Fluted Brass Tube, One Foot Long.

3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1¼	1½
oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
2¾	3¼	3½	4	5	6	7	8	11	14

Square Bar Brass, One Foot Long.

¼	3/8	½	5/8	¾	7/8	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜	2½	2⅝	2¾	2⅞	3
lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·22	·5	·9	1·4	2·02	2·75	3·6	4·56	5·63	6·81	8·1	9·51	11·03	12·7	14·41	16·3	18·3	20·4	22·6	24·9	27·3	29·8	32·5

Brass Balls, per Inches Diameter.

1	1½	2	2½	3	3½	4	4½	5	5½	6	7	8	9	10	11	12
lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·158	·537	1·25	2·5	4·3	6·82	10·2	14·25	20·	26·5	34·3	54·5	81·4	116·	159·	212·	275·

WEIGHTS OF COPPER, ZINC, TIN, AND IRON.

NEXT to brass and the alloys rank copper, zinc, tin, and iron in importance to the brassfounder; and as these metals are always in demand, we have annexed the following tables of weights, which we have no doubt will be found of use.

Should these tables not furnish exactly the sizes required for any special calculation, the result required will be found by taking the weight in wrought iron, and multiplying it by

1·09 for brass,
1·15 for copper,
1·48 for lead,
0·94 for tin,
0·92 for zinc,
1·01 for steel

WEIGHTS OF COPPER.

SHEET COPPER, ONE FOOT SQUARE, BY WIRE GAUGE NUMBERS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
14·5	13·2	12·8	11·6	10·2	9·4	8·7	7·9	7·2	6·5	5·8	5·1	4·4	3·6	3·3	2·9	2·3	2·2	2·0	1·8	1·7	1·5	1·3	1·2	1·0	·9

PLATES OF COPPER, ONE FOOT SQUARE, BY PARTS OF INCHES.

1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2·9	5·8	8·7	11·6	14·5	17·3	20·2	23·1	26·0	28·9	31·8	34·7	37·5	40·4	43·3	46·2

SQUARE BAR COPPER, ONE FOOT LONG, BY PARTS OF INCHES.

1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·24	·54	·96	1·5	2·16	2·94	3·84	4·86	6·0	7·27	8 65	10·15	11·77	13·5	15·4

ROUND BAR COPPER, ONE FOOT LONG, BY PARTS OF INCHES.

¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2
lb.	lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·188	·424	·755	1·17	1·69	2 31	3·1	3·82	4·71	5·71	6·79	7·94	9·21	10·61	12·1

COPPER TUBES ONE-EIGHTH THICK, ONE FOOT LONG.

½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3
lb.	lb.	lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs	lbs.	lbs.
·94	1·14	1·33	1·51	1·69	1·89	2·08	2·23	2 42	2·67	2·87	3·03	3·21	3·58	3·97	4·34	4·73

COPPER BALLS, PER INCHES DIAMETER.

1	1½	2	2½	3	3½	4	4½	5	5½	6	7	8	9	10	11	12
lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·166	·56	1·3	2·6	4·5	7·14	10·7	15·25	20·8	2[illegible]·74	35·9	57·1	85·2	121·3	166·4	221·8	288·1

WEIGHTS OF ZINC.

Sheet Zinc, One Foot Square, by Wire Gauge Numbers.

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
5·2	4·6	4·1	3·5	2·8	2·6	2·3	2·1	1·8	1·7	1·5	1·4	1·2	1·1	1·0	·9	·8	·7

Plates of Zinc, One Foot Square, by Parts of Inches.

1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2·3	4·7	7·0	9·4	11·7	14·0	16·4	18·7	21·1	23·4	25·7	28·1	30·4	32·8	35·1	37·5

Square Bar Zinc, One Foot Long, by Parts of Inches.

1/4	1/2	3/4	1	1¼	1½	1¾	2	2½	3	3½	4	4½	5	5½	6
lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
·2	·8	2·8	2·8	4·9	6·8	9·5	12·3	19·2	27·7	37·8	49·2	62·2	75·9	102·2	110·7

ROUND ROD ZINC, ONE FOOT LONG, BY PARTS OF INCHES.

$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6
lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	[illegible]s.	[illegible]	lbs.
·16	·65	1·4	2·5	3·8	5·3	7·3	9·7	15·1	21·8	29·6	38·6	48·8	60·3	73·5	87

WEIGHTS OF TIN.

PLATES OF TIN, ONE FOOT SQUARE, BY PARTS OF INCHES.

$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2·4	4·8	7·3	9·5	11·9	14·3	16·17	19·0	21·4	23·8	26 2	28·5	30·9	33·3	35·7	38·0

ORDINARY BLOCK-TIN TUBES, BY DIAMETER OF BORE.

$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$		$1\frac{1}{2}$
oz.	oz.	oz.	oz.	oz.	oz.	lbs.	oz.	lbs.
5·5	7·0	9·0	13·0	1[illegible]·0	30·0	2	13	4·0

TINNED PLATES.

Brand Mark.	No. of Sheets in a Box.	Dimensions.		Weight of a Box.		
		Length.	Breadth.	cwt.	qrs.	lbs.
1 C	225	13¾	10	1	0	0
2 C	225	13¼	9¾	...	3	21
3 C	225	12¾	9½	...	3	14
H C............	225	13¾	10	1	0	7
Hx	225	13¾	10	1	1	7
1x	225	13¾	10	1	1	0
2x	225	13¼	9¾	1	0	21
3x	225	12¾	9½	1	0	14
1xx	225	13¾	10	1	1	21
1xxx	225	13¾	10	1	2	14
1xxxx	225	13¾	10	1	3	7
D C............	100	16¾	12½	...	3	21
Dx	100	16¾	12½	1	0	14
Dxx	100	16¾	12½	1	1	7
Dxxx	100	16¾	12½	1	2	0
Dxxxx	100	16¾	12½	1	2	21
S D C	200	15	11	1	2	0
S Dx	200	15	11	1	2	21
S Dxx..........	200	15	11	1	3	14
S Dxxx	200	15	11	2	0	7
S Dxxxx........	200	15	11	2	1	0
Wasters, W C and X Mixed......	225	13¾	10	1	0	14
T T............	450	13¾	10	1	0	0
X T T..........	450	13¾	10	1	0	14

ONE BOX OF

WEIGHTS OF LEAD

Sheet Lead, One Foot Square, by Parts of Inches.

$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3·7	7·4	11·1	14·8	18·5	22·2	25·9	29·5	33·2	36·9	40·6	44·3	48·0	51·7	55·4	59·1

Square Bar Lead, One Foot Long, by Parts of Inches.

1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3 in.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
4·93	6·25	7·71	9·33	11·11	13·1	15·2	17·4	19·8	22·3	25·0	27·8	30·9	34·1	37·4	40·9	44·6

Round Bar Lead, One Foot Long, by Parts of Inches.

1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3 in.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3·8	4·9	6·1	7·4	8·8	10·3	11·8	13·[illegible]	15·6	17·6	19·7	21·8	24·3	26·8	29·4	32·1	34·9

Lead Pipes, One-eighth Thick.

1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3 in.
lbs.	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2·19	2·4	2·66	2·91	3·15	3·39	3·64	3·88	4·12	4·29	4·61	4·92	5·1	5·33	5·57	5·82	6·06

Lead Pipes, One-quarter Thick.

1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3 in.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
4·85	5·34	5·81	6·3	6·8	7·3	7·76	8·2	8·73	9·21	9·7	10·3	10·7	11·2	11·7	12·2	12·6

WEIGHTS OF IRON.

Sheet Iron, One Foot Square, by Birmingham Wire Gauge.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
12·6	11·3	10·5	9·6	8·7	8·4	7·5	6·7	6·3	5·5	4·8	4·3	3·7	3·3	3 0	2·7	2·2	2·0	1·7	1·5	1·4	1·2	1·0	·95	·84

PLATES OF IRON, ONE FOOT SQUARE, BY PARTS OF INCHES.

$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2·5	5·0	7·5	10·0	12·5	15·0	17·5	20	22·5	25·0	27·5	30·0	32·5	35·0	37·5	40·0

SQUARE BAR IRON, ONE FOOT LONG, BY PARTS OF INCHES.

$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs.
·21	·33	·47	·64	·86	1·1	1·3	1·6	1·9	2·2	2·6	3·0	3·4

ROUND ROD IRON, ONE FOOT LONG, BY PARTS OF INCHES.

$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.
·17	·26	·37	·51	·66	·8	1·1	1·3	1·5	1·8	2·1	2·4	2·7

FLAT IRON, ONE INCH BY PARTS OF INCH, ONE FOOT LONG.

$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1 in.
lb.	lb.	lb.	lb.	lb.	lbs.	lbs.	lbs.	lbs
·83	1·04	1·25	1·46	1·67	2·08	2·50	2·92	3·34

TABLES FOR CONVERSIONS INTO DECIMALS.

OUNCES INTO DECIMAL PARTS OF A POUND AVOIRDUPOIS.

1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8 oz.	
·06	·09	·12	·15	·19	·22	·25	·28	·31	·34	·37	·40	·43	·46	·50	
8½	9	9½	10	10½	11	11½	12	12½	13	13½	14	14½	15	15½	16 oz.
·53	·56	·59	·62	·65	·69	·72	·75	·78	·81	·84	·87	·90	·94	·97	1·0

POUNDS AVOIRDUPOIS INTO DECIMAL PARTS OF ONE HUNDREDWEIGHT

qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.
0	0½	=·0044	1	0	= ·25	2	0	=·5	3	0	=·75
0	1	·0089	1	1	·2589	2	1	·5089	3	1	·7589
0	2	·0178	1	2	·2678	2	2	·5178	3	2	·7678
0	3	·0268	1	3	·2768	2	3	·5268	3	3	·7768
0	4	·0357	1	4	·2857	2	4	·5357	3	4	·7857
0	5	·0446	1	5	·2946	2	5	·5446	3	5	·7946
0	6	·0535	1	6	·3035	2	6	·5535	3	6	·8035
0	7	·0625	1	7	·3125	2	7	·5625	3	7	·8125
0	8	·0714	1	8	·3214	2	8	·5714	3	8	·8214
0	9	·0803	1	9	·3303	2	9	·5803	3	9	·8303
0	10	·0892	1	10	·3392	2	10	·5892	3	10	·8392
0	11	·0982	1	11	·3482	2	11	·5982	3	11	·8482
0	12	·1071	1	12	·3571	2	12	·6077	3	12	·8571
0	13	·1160	1	13	·3660	2	13	·6160	3	13	·8660
0	14	·125	1	14	·375	2	14	·625	3	14	·875
0	15	·1339	1	15	·3839	2	15	·6339	3	15	·8839
0	16	·1429	1	16	·3929	2	16	·6429	3	16	·8929
0	17	·1518	1	17	·4018	2	17	·6518	3	17	·9018
0	18	·1607	1	18	·4107	2	18	·6607	3	18	·9107
0	19	·1696	1	19	·4196	2	19	·6696	3	19	·9196
0	20	·1786	1	20	·4286	2	20	·6786	3	20	·9286
0	21	·1876	1	21	·4375	2	21	·6875	3	21	·9375
0	22	·1964	1	22	·4464	2	22	·6964	3	22	·9464
0	23	·2054	1	23	·4554	2	23	·7054	3	23	·9554
0	24	·2143	1	24	·4643	2	24	·7143	3	24	·9643
0	25	·2232	1	25	·4732	2	25	·7232	3	25	·9732
0	26	·2321	1	26	·4821	2	26	·7321	3	26	·9821
0	27	·2411	1	27	·4911	2	27	·7411	3	27	·9911

SQUARE INCHES INTO DECIMAL PARTS OF 1 FT. SQUARE.

144"	130"	115"	100"	87"	72"	57"	43"	28"	14"
1·00	·90	·80	·70	·60	·50	·40	·30	·20	·10
13"	11"	10"	9"	8"	7"	6"	4"·3	2"·9	1"·4
·9	·8	·7	·6	·5·6	·5	·4	·3	·2	·1

BIRMINGHAM WIRE GAUGE, INTO DECIMAL PARTS OF ONE INCH

B.W.G. = in.	B.W.G. = in.	B.W.G. = in.	B.W.G. = in.
No. 1 = ·31	No. 10 = ·134	No. 19 = ·042	No. 28 = ·014
2 ·28	11 ·125	20 ·035	29 ·013
3 ·26	12 ·109	21 ·032	30 ·012
4 ·24	13 ·095	22 ·028	31 ·01
5 ·22	14 ·083	23 ·025	32 ·009
6 ·2	15 ·072	24 ·022	33 ·008
7 ·187	16 ·065	25 ·02	34 ·007
8 ·166	17 ·056	26 ·018	35 ·005
9 ·158	18 ·049	27 ·016	36 ·004

SURFACE OF TUBES, ONE FOOT LONG, BY DIAMETER, INTO DECIMAL PARTS OF SQUARE FEET.

Bore..	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Surface	·1636	·1963	·2291	·2618	·2945	·3270	·3599	·3927
Bore..	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4	3
Surface	·4253	·4580	·4906	·5233	·5890	·6544	·7199	·7854

THE HUNDREDWEIGHT RECKONER,

SO FAR AS IS USEFUL TO THE BRASSFOUNDER.

THE following tables reckon from 3*d.* to 1*s.* 6*d.* per pound. By doubling the amount the reckoning gives easily to 3*s.* per pound, which embraces the limits, generally, of a brassfounder.

THE HUNDREDWEIGHT RECKONER.

3*d.* per lb., or 28*s.* per cwt.

lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*
				1 0	is	7	0	2 0	is	14	0	3 0	is	21	0
1	is	0	3	1 1	,,	7	3	2 1	,,	14	3	3 1	,,	21	3
2	,,	0	6	1 2	,,	7	6	2 2	,,	14	6	3 2	,,	21	6
3	,,	0	9	1 3	,,	7	9	2 3	,,	14	9	3 3	,,	21	9
4	,,	1	0	1 4	,,	8	0	2 4	,,	15	0	3 4	,,	22	0
5	,,	1	3	1 5	,,	8	3	2 5	,,	15	3	3 5	,,	22	3
6	,,	1	6	1 6	,,	8	6	2 6	,,	15	6	3 6	,,	22	6
7	,,	1	9	1 7	,,	8	9	2 7	,,	15	9	3 7	,,	22	9
8	,,	2	0	1 8	,,	9	0	2 8	,,	16	0	3 8	,,	23	0
9	,,	2	3	1 9	,,	9	3	2 9	,,	16	3	3 9	,,	23	3
10	,,	2	6	1 10	,,	9	6	2 10	,,	16	6	3 10	,,	23	6
11	,,	2	9	1 11	,,	9	9	2 11	,,	16	9	3 11	,,	23	9
12	,,	3	0	1 12	,,	10	0	2 12	,,	17	0	3 12	,,	24	0
13	,,	3	3	1 13	,,	10	3	2 13	,,	17	3	3 13	,,	24	3
14	,,	3	6	1 14	,,	10	6	2 14	,,	17	6	3 14	,,	24	6
15	,,	3	9	1 15	,,	10	9	2 15	,,	17	9	3 15	,,	24	9
16	,,	4	0	1 16	,,	11	0	2 16	,,	18	0	3 16	,,	25	0
17	,,	4	3	1 17	,,	11	3	2 17	,,	18	3	3 17	,,	25	3
18	,,	4	6	1 18	,,	11	6	2 18	,,	18	6	3 18	,,	25	6
19	,,	4	9	1 19	,,	11	9	2 19	,,	18	9	3 19	,,	25	9
20	,,	5	0	1 20	,,	12	0	2 20	,,	19	0	3 20	,,	26	0
21	,,	5	3	1 21	,,	12	3	2 21	,,	19	3	3 21	,,	26	3
22	,,	5	6	1 22	,,	12	6	2 22	,,	19	6	3 22	,,	26	6
23	,,	5	9	1 23	,,	12	9	2 23	,,	19	9	3 23	,,	26	9
24	,,	6	0	1 24	,,	13	0	2 24	,,	20	0	3 24	,,	27	0
25	,,	6	3	1 25	,,	13	3	2 25	,,	20	3	3 25	,,	27	3
26	,,	6	6	1 26	,,	13	6	2 26	,,	20	6	3 26	,,	27	6
27	,,	6	9	1 27	,,	13	9	2 27	,,	20	9	3 27	,,	27	9

The Hundredweight Reckoner.

4*d.* per lb., or 37*s.* 4*d.* per cwt.

lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*
				1 0	is	9	4	2 0	is	18	8	3 0	is	28	0
1	is	0	4	1 1	,,	9	8	2 1	,,	19	0	3 1	,,	28	4
2	,,	0	8	1 2	,,	10	0	2 2	,,	19	4	3 2	,,	28	8
3	,,	1	0	1 3	,,	10	4	2 3	,,	19	8	3 3	,,	29	0
4	,,	1	4	1 4	,,	10	8	2 4	,,	20	0	3 4	,,	29	4
5	,,	1	8	1 5	,,	11	0	2 5	,,	20	4	3 5	,,	29	8
6	,,	2	0	1 6	,,	11	4	2 6	,,	20	8	3 6	,,	30	0
7	,,	2	4	1 7	,,	11	8	2 7	,,	21	0	3 7	,,	30	4
8	,,	2	8	1 8	,,	12	0	2 8	,,	21	4	3 8	,,	30	8
[illegible]		3	0	1 9	,,	12	4	2 9	,,	21	8	3 9	,,	31	0
10	,,	3	4	1 10	,,	12	8	2 10	,,	22	0	3 10	,,	31	4
11	,,	3	8	1 11	,,	13	0	2 11	,,	22	4	3 11	,,	31	8
12	,,	4	0	1 12	,,	13	4	2 12	,,	22	8	3 12	,,	32	0
13	,,	4	4	1 13	,,	13	8	2 13	,,	23	0	3 13	,,	32	4
14	,,	4	8	1 14	,,	14	0	2 14	,,	23	4	3 14	,,	32	8
15	,,	5	0	1 15	,,	14	4	2 15	,,	23	8	3 15	,,	33	0
16	,,	5	4	1 16	,,	14	8	2 16	,,	24	0	3 16	,,	33	4
17	,,	5	8	1 17	,,	15	0	2 17	,,	24	4	3 17	,,	33	8
18	,,	6	0	1 18	,,	15	4	2 18	,,	24	8	3 18	,,	34	0
19	,,	6	4	1 19	,,	15	8	2 19	,,	25	0	3 19	,,	34	4
20	,,	6	8	1 20	,,	16	0	2 20	,,	25	4	3 20	,,	34	8
21	,,	7	0	1 21	,,	16	4	2 21	,,	25	8	3 21	,,	35	0
22	,,	7	4	1 22	,,	16	8	2 22	,,	26	0	3 22	,,	35	4
23	,,	7	8	1 23	,,	17	0	2 23	,,	26	4	3 23	,,	35	8
24	,,	8	0	1 24	,,	17	4	2 24	,,	26	8	3 24	,,	36	0
25	,,	8	4	1 25	,,	17	8	2 25	,,	27	0	3 25	,,	36	4
26	,,	8	8	1 26	,,	18	[illegible]	2 26	,,	27	4	3 26	,,	36	8
27	,,	[illegible]	[illegible]	1 27	,,	18	4	2 27	,,	27	[illegible]	3 27	,,	37	0

THE HUNDREDWEIGHT RECKONER.

5d. per lb., or 46*s.* 8*d.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	11	8	2	0	is	23	4	3	0	is	35	0
1	is	0	5	1	1	,,	12	1	2	1	,,	23	9	3	1	,,	35	5
2	,,	0	10	1	2	,,	12	6	2	2	,,	24	2	3	2	,,	35	10
3	,,	1	3	1	3	,,	12	11	2	3	,,	24	7	3	3	,,	36	3
4	,,	1	8	1	4	,,	13	4	2	4	,,	25	0	3	4	,,	36	8
5	,,	2	1	1	5	,,	13	9	2	5	,,	25	5	3	5	,,	37	1
6	,,	2	6	1	6	,,	14	2	2	6	,,	25	10	3	6	,,	37	6
7	,,	2	11	1	7	,,	14	7	2	7	,,	26	3	3	7	,,	37	11
8	,,	3	4	1	8	,,	15	0	2	8	,,	26	8	3	8	,,	38	4
9	,,	3	9	1	9	,,	15	5	2	9	,,	27	1	3	9	,,	38	9
10	,,	4	2	1	10	,,	15	10	2	10	,,	27	6	3	10	,,	39	2
11	,,	4	7	1	11	,,	16	3	2	11	,,	27	11	3	11	,,	39	7
12	,,	5	0	1	12	,,	16	8	2	12	,,	28	4	3	12	,,	40	0
13	,,	5	5	1	13	,,	17	1	2	13	,,	28	9	3	13	,,	40	5
14	,,	5	10	1	14	,,	17	6	2	14	,,	29	2	3	14	,,	40	10
15	,,	6	3	1	15	,,	17	11	2	15	,,	29	7	3	15	,,	41	3
16	,,	6	8	1	16	,,	18	4	2	16	,,	30	0	3	16	,,	41	8
17	,,	7	1	1	17	,,	18	9	2	17	,,	30	5	3	17	,,	42	1
18	,,	7	6	1	18	,,	19	2	2	18	,,	30	10	3	18	,,	42	6
19	,,	7	11	1	19	,,	19	7	2	19	,,	31	3	3	19	,,	42	11
20	,,	8	4	1	20	,,	20	0	2	20	,,	31	8	3	20	,,	43	4
21	,,	8	9	1	21	,,	20	5	2	21	,,	32	1	3	21	,,	43	9
22	,,	9	2	1	22	,,	20	10	2	22	,,	32	6	3	22	,,	44	2
23	,,	9	7	1	23	,,	21	3	2	23	,,	32	11	3	23	,,	44	7
24	,,	10	0	1	24	,,	21	8	2	24	,,	33	4	3	24	,,	45	0
25	,,	10	5	1	25	,,	22	1	2	25	,,	33	9	3	25	,,	45	5
26	,,	10	10	1	26	,,	22	6	2	26	,,	34	2	3	26	,,	45	10
27	,,	11	3	1	27	,,	22	11	2	27	,,	34	7	3	27	,,	46	3

THE HUNDREDWEIGHT RECKONER.

6d. per lb., or *56s.* per cwt.

lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.
				1	0	is	14	0	2	0	is	28	0	3	0	is	42	0
1	is	0	6	1	1	,,	14	6	2	1	,,	28	6	3	1	,,	42	6
2	,,	1	0	1	2	,,	15	0	2	2	,,	29	0	3	2	,,	43	0
3	,,	1	6	1	3	,	15	6	2	3	,,	29	6	3	3	,,	43	6
4	,,	2	0	1	4	,,	16	0	2	4	,,	30	[illegible]	3	4	,,	44	0
5	,,	2	6	1	5	,,	16	6	2	5	,,	30	6	3	5	,,	44	6
6	,,	3	0	1	6	,,	17	0	2	6	,,	31	0	3	6	,,	45	0
7	,,	3	6	1	7	,,	17	6	2	7	,,	31	6	3	7	,,	45	6
8	,,	4	0	1	8	,,	18	0	2	8	,,	32	0	3	8	,,	46	0
9	,,	4	6	1	9	,,	18	[illegible]	2	9	,,	32	6	3	9	,,	46	6
10	,,	5	[illegible]	1	10	,,	19	0	2	10	,,	33	0	3	10	,,	47	0
11	,,	5	6	1	11	,,	19	6	2	11	,,	33	6	3	11	,,	47	6
12	,,	6	0	1	12	,,	20	0	2	12	,,	34	0	3	12	,,	48	0
13	,,	6	6	1	13	,,	20	6	2	13	,,	34	6	3	13	,,	48	6
14	,,	7	0	1	14	,,	21	0	2	14	,,	35	0	3	14	,,	49	0
15	,,	7	6	1	15	,,	21	6	2	15	,,	35	6	3	15	,,	49	6
16	,,	8	0	1	16	,,	22	0	2	16	,,	36	0	3	16	,,	50	0
17	,,	8	6	1	17	,,	22	6	2	17	,,	36	6	3	17	,,	50	6
18	,,	9	0	1	18	,,	23	0	2	18	,,	37	0	3	18	,,	51	0
19	,,	9	6	1	19	,,	23	6	2	19	,,	37	6	3	19	,,	51	6
20		10	0	1	20	,,	24	0	2	20	,,	38	0	3	20	,,	52	0
21	,,	10	6	1	21	,,	24	6	2	21	,,	38	6	3	21	,,	52	6
22	,,	11	[illegible]	1	22	,,	25	0	2	22	,,	39	0	3	22	,,	53	0
23	,,	11	6	1	23	,,	25	6	2	23	,,	39	6	3	23	,,	53	6
24	,,	12	0	1	24	,,	26	0	2	24	,,	40	0	3	24	,,	54	0
25	,,	12	6	1	25	,,	26	6	2	25	,,	40	6	3	25	,,	54	6
26	,,	13	0	1	26	,,	27	0	2	26	,,	41	0	3	26	,,	55	0
27	,,	13	[illegible]	1	27	,,	27	6	2	27	,,	41	6	3	27	,,	55	6

The Hundredweight Reckoner.

7d. per lb., or *65s. 4d.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	16	4	2	0	is	32	8	3	0	is	49	0
1	is	0	7	1	1	,,	16	11	2	1	,,	33	3	3	1	,,	49	7
2	,,	1	2	1	2	,,	17	6	2	2	,,	33	10	3	2	,,	50	2
3	,,	1	9	1	3	,,	18	1	2	3	,,	34	5	3	3	,,	50	9
4	,,	2	4	1	4	,,	18	8	2	4	,,	35	0	3	4	,,	51	4
5	,,	2	11	1	5	,,	19	3	2	5	,,	35	7	3	5	,,	51	11
6	,,	3	6	1	6	,,	19	10	2	6	,,	36	2	3	6	,,	52	6
7	,,	4	1	1	7	,,	20	5	2	7	,,	36	9	3	7	,,	53	1
8	,,	4	8	1	8	,,	21	0	2	8	,,	37	4	3	8	,,	53	8
9	,,	5	3	1	9	,,	21	7	2	9	,,	37	11	3	9	,,	54	3
10	,,	5	10	1	10	,,	22	2	2	10	,,	38	6	3	10	,,	54	10
11	,,	6	5	1	11	,,	22	9	2	11	,,	39	1	3	11	,,	55	5
12	,,	7	0	1	12	,,	23	4	2	12	,,	39	8	3	12	,,	56	0
13	,,	7	7	1	13	,,	23	11	2	13	,,	40	3	3	13	,,	56	7
14	,,	8	2	1	14	,,	24	6	2	14	,,	40	10	3	14	,,	57	2
15	,,	8	9	1	15	,,	25	1	2	15	,,	41	5	3	15	,,	57	9
16	,,	9	4	1	16	,,	25	8	2	16	,,	42	0	3	16	,,	58	4
17	,,	9	11	1	17	,,	26	3	2	17	,,	42	7	3	17	,,	58	11
18	,,	10	6	1	18	,,	26	10	2	18	,,	43	2	3	18	,,	59	6
19	,,	11	1	1	19	,,	27	5	2	19	,,	43	9	3	19	,,	60	1
20	,,	11	8	1	20	,,	28	0	2	20	,,	44	4	3	20	,,	60	8
21	,,	12	3	1	21	,,	28	7	2	21	,,	44	11	3	21	,,	61	3
22	,,	12	10	1	22	,,	29	2	2	22	,,	45	6	3	22	,,	61	10
23	,,	13	5	1	23	,,	29	9	2	23	,,	46	1	3	23	,,	62	5
24	,,	14	0	1	24	,,	30	4	2	24	,,	46	8	3	24	,,	63	0
25	,,	14	7	1	25	,,	30	11	2	25	,,	47	3	3	25	,,	63	7
26	,,	15	2	1	26	,,	31	6	2	26	,,	47	10	3	26	,,	64	2
27	,,	15	9	1	27	,,	32	1	2	27	,,	48	5	3	27	,,	64	9

THE HUNDREDWEIGHT RECKONER.

8*d.* per lb., or 74*s.* 8*d.* per cwt.

lbs.	*s.*	*d.*	qrs. lbs.	*s.*	*d.*	qrs. lbs.	*s.*	*d.*	qrs. lbs.	*s.*	*d.*
			1 0 is	18	8	2 0 is	37	4	3 0 is	56	0
1 is	0	8	1 1 „	19	4	2 1 „	38	0	3 1 „	56	8
2 „	1	4	1 2 „	20	0	2 2 „	38	8	3 2 „	57	4
3 „	2	0	1 3 „	20	8	2 3 „	39	4	3 3 „	58	0
4 „	2	8	1 4 „	21	4	2 4 „	40	0	3 4 „	58	8
5 „	3	4	1 5 „	22	0	2 5 „	40	8	3 5 „	59	4
6 „	4	0	1 6 „	22	8	2 6 „	41	4	3 6 „	60	0
7 „	4	8	1 7 „	23	4	2 7 „	42	0	3 7 „	60	8
8 „	5	4	1 8 „	24	0	2 8 „	42	8	3 8 „	61	4
9 „	6	0	1 9 „	24	8	2 9 „	43	4	3 9 „	62	0
10 „	6	8	1 10 „	25	4	2 10 „	44	0	3 10 „	62	8
11 „	7	4	1 11 „	26	0	2 11 „	44	8	3 11 „	63	4
12 „	8	0	1 12 „	26	8	2 12 „	45	4	3 12 „	64	0
13 „	8	8	1 13 „	27	4	2 13 „	46	0	3 13 „	64	8
14 „	9	4	1 14 „	28	0	2 14 „	46	8	3 14 „	65	4
15 „	10	0	1 15 „	28	8	2 15 „	47	4	3 15 „	66	0
16 „	10	8	1 16 „	29	4	2 16 „	48	0	3 16 „	66	8
17 „	11	4	1 17 „	30	0	2 17 „	48	8	3 17 „	67	4
18 „	12	0	1 18 „	30	8	2 18 „	49	4	3 18 „	68	0
19 „	12	8	1 19 „	31	4	2 19 „	50	0	3 19 „	68	8
20 „	13	4	1 20 „	32	0	2 20 „	50	8	3 20 „	69	4
21 „	14	0	1 21 „	32	8	2 21 „	51	4	3 21 „	70	0
22 „	14	8	1 22 „	33	4	2 22 „	52	0	3 22 „	70	8
23 „	15	4	1 23 „	34	0	2 23 „	52	8	3 23 „	71	4
24 „	16	0	1 24 „	34	8	2 24 „	53	4	3 24 „	72	0
25 „	16	8	1 25 „	35	4	2 25 „	54	0	3 25 „	72	8
26 „	17	4	1 26 „	36	0	2 26 „	54	8	3 26 „	73	4
27 „	18	[illegible]	1 27 „	36	8	2 27 „	55	4	3 27 „	74	0

THE HUNDREDWEIGHT RECKONER.

9*d.* per lb., or 84*s.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	21	0	2	0	is	42	0	3	0	is	63	0
1	is	0	9	1	1	,,	21	9	2	1	,,	42	9	3	1	,,	63	9
2	,,	1	6	1	2	,,	22	6	2	2	,,	43	6	3	2	,,	64	6
3	,,	2	3	1	3	,,	23	3	2	3	,,	44	3	3	3	,,	65	3
4	,,	3	0	1	4	,,	24	0	2	4	,,	45	0	3	4	,,	66	0
5	,,	3	9	1	5	,,	24	9	2	5	,,	45	9	3	5	,,	66	9
6	,,	4	6	1	6	,,	25	6	2	6	,,	46	6	3	6	,,	67	6
7	,,	5	3	1	7	,,	26	3	2	7	,,	47	3	3	7	,,	68	3
8	,,	6	0	1	8	,,	27	0	2	8	,,	48	0	3	8	,,	69	0
9	,,	6	9	1	9	,,	27	9	2	9	,,	48	9	3	9	,,	69	9
10	,,	7	6	1	10	,,	28	6	2	10	,,	49	6	3	10	,,	70	6
11	,,	8	3	1	11	,,	29	3	2	11	,,	50	3	3	11	,,	71	3
12	,,	9	0	1	12	,,	30	0	2	12	,,	51	0	3	12	,,	72	0
13	,,	9	9	1	13	,,	30	9	2	13	,,	51	9	3	13	,,	72	9
14	,,	10	6	1	14	,,	31	6	2	14	,,	52	6	3	14	,,	73	6
15	,,	11	3	1	15	,,	32	3	2	15	,,	53	3	3	15	,,	74	3
16	,,	12	0	1	16	,,	33	0	2	16	,,	54	0	3	16	,,	75	0
17	,,	12	9	1	17	,,	33	9	2	17	,,	54	9	3	17	,,	75	9
18	,,	13	6	1	18	,,	34	6	2	18	,,	55	6	3	18	,,	76	6
19	,,	14	3	1	19	,,	35	3	2	19	,,	56	3	3	19	,,	77	3
20	,,	15	0	1	20	,,	36	0	2	20	,,	57	0	3	20	,,	78	0
21	,,	15	9	1	21	,,	36	9	2	21	,,	57	9	3	21	,,	78	9
22	,,	16	6	1	22	,,	37	6	2	22	,,	58	6	3	22	,,	79	6
23	,,	17	3	1	23	,,	38	3	2	23	,,	59	3	3	23	,,	80	3
24	,,	18	0	1	24	,,	39	0	2	24	,,	60	0	3	24	,,	81	0
25	,,	18	9	1	25	,,	39	9	2	25	,,	60	9	3	25	,,	81	9
26	,,	19	6	1	26	,,	40	6	2	26	,,	61	6	3	26	,,	82	6
27	,,	20	3	1	27	,,	41	3	2	27	,,	62	3	3	27	,,	83	3

The Hundredweight Reckoner.

10*d.* per lb., or 93*s.* 4*d.* per cwt.

lbs.	s.	d.	qrs.	lbs.	s.	d.	qrs.	lbs.	s.	d.	qrs.	lbs.	s.	d.
			1	0 is	23	4	2	0 is	46	8	3	0 is	70	0
1 is	0	10	1	1 „	24	2	2	1 „	47	6	3	1 „	70	10
2 „	1	8	1	2 „	25	0	2	2 „	48	4	3	2 „	71	8
3 „	2	6	1	3 „	25	10	2	3 „	49	2	3	3 „	72	6
4 „	3	4	1	4 „	26	8	2	4 „	50	0	3	4 „	73	4
5 „	4	2	1	5 „	27	6	2	5 „	50	10	3	5 „	74	2
6 „	5	0	1	6 „	28	4	2	6 „	51	8	3	6 „	75	0
7 „	5	10	1	7 „	29	2	2	7 „	52	6	3	7 „	75	10
8 „	6	8	1	8 „	30	0	2	8 „	53	4	3	8 „	76	8
9 „	7	6	1	9 „	30	10	2	9 „	54	2	3	9 „	77	6
10 „	8	4	1	10 „	31	8	2	10 „	55	0	3	10 „	78	4
11 „	9	2	1	11 „	32	6	2	11 „	55	10	3	11 „	79	2
12 „	10	0	1	12 „	33	4	2	12 „	56	8	3	12 „	80	0
13 „	10	10	1	13 „	34	2	2	13 „	57	6	3	13 „	80	10
14 „	11	8	1	14 „	35	0	2	14 „	58	4	3	14 „	81	8
15 „	12	6	1	15 „	35	10	2	15 „	59	2	3	15 „	82	6
16 „	13	4	1	16 „	36	8	2	16 „	60	0	3	16 „	83	4
17 „	14	2	1	17 „	37	6	2	17 „	60	10	3	17 „	84	2
18 „	15	0	1	18 „	38	4	2	18 „	61	8	3	18 „	85	0
19 „	15	10	1	19 „	39	2	2	19 „	62	6	3	19 „	85	10
20 „	16	8	1	20 „	40	0	2	20 „	63	4	3	20 „	86	8
21 „	17	6	1	21 „	40	10	2	21 „	64	2	3	21 „	87	6
22 „	18	4	1	22 „	41	8	2	22 „	65	0	3	22 „	88	4
23 „	19	2	1	23 „	42	6	2	23 „	65	10	3	23 „	89	2
24 „	20	0	1	24 „	43	4	2	24 „	66	8	3	24 „	90	0
25 „	20	10	1	25 „	44	2	2	25 „	67	6	3	25 „	90	10
26 „	21	8	1	26 „	45	0	2	26 „	68	4	3	26 „	91	8
27 „	22	6	1	27 „	45	10	2	27 „	69	2	3	27 „	92	6

THE HUNDREDWEIGHT RECKONER.

11*d.* per lb., or 102*s.* 8*d.* per cwt.

lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.
				1	0	is	25	8	2	0	is	51	4	3	0	is	77	0
1	is	0	11	1	1	„	26	7	2	1	„	52	3	3	1	„	77	11
2	„	1	10	1	2	„	27	6	2	2	„	53	2	3	2	„	78	10
3	„	2	9	1	3	„	28	5	2	3	„	54	1	3	3	„	79	9
4	„	3	8	1	4	„	29	4	2	4	„	55	0	3	4	„	80	8
5	„	4	7	1	5	„	30	3	2	5	„	55	11	3	5	„	81	[illegible]
6	„	5	6	1	6	„	31	2	2	6	„	56	10	3	6	„	82	6
7	„	6	5	1	7	„	32	1	2	7	„	57	9	3	7	„	83	5
8	„	7	4	1	8	„	33	0	2	8	„	58	8	3	8	„	84	4
9	„	8	3	1	9	„	33	11	2	9	„	59	7	3	9	„	85	3
10	„	9	2	1	10	„	34	10	2	10	„	60	6	3	10	„	86	2
11	„	10	1	1	11	„	35	9	2	11	„	61	5	3	11	„	87	1
12	„	11	0	1	12	„	36	8	2	12	„	62	4	3	12	„	88	0
13	„	11	11	1	13	„	37	7	2	13	„	63	3	3	13	„	88	11
14	„	12	10	1	14	„	38	6	2	14	„	64	2	3	14	„	89	10
15	„	13	9	1	15	„	39	5	2	15	„	65	1	3	15	„	90	9
16	„	14	8	1	16	„	40	4	2	16	„	66	0	3	16	„	91	8
17	„	15	7	1	17	„	41	3	2	17	„	66	11	3	17	„	92	7
18	„	16	6	1	18	„	42	2	2	18	„	67	10	3	18	„	93	6
19	„	17	5	1	19	„	43	1	2	19	„	68	9	3	19	„	94	5
20	„	18	4	1	20	„	44	0	2	20	„	69	8	3	20	„	95	4
21	„	19	3	1	21	„	44	11	2	21	„	70	7	3	21	„	96	3
22	„	20	2	1	22	„	45	10	2	22	„	71	6	3	22	„	97	2
23	„	21	1	1	23	„	46	9	2	23	„	72	5	3	23	„	98	1
24	„	22	0	1	24	„	47	8	2	24	„	73	4	3	24	„	99	0
25	„	22	11	1	25	„	48	7	2	25	„	74	3	3	25	„	99	11
26	„	23	10	1	26	„	49	6	2	26	„	75	2	3	26	„	100	10
27	„	24	9	1	27	„	50	5	2	27	„	76	1	3	27	„	101	9

THE HUNDREDWEIGHT RECKONER.

1*s.* 1*d.* per lb., or 121*s.* 4*d.* per cwt.

lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d.*	qrs. lbs.		*s.*	*d*
				1 0	is	30	4	2 0	is	60	8	3 0	is	91	0
1	is	1	1	1 1	„	31	5	2 1	„	61	9	3 1	„	92	1
2	„	2	2	1 2	„	32	6	2 2	„	62	10	3 2	„	93	2
3	„	3	3	1 3	„	33	7	2 3	„	63	11	3 3	„	94	3
4	„	4	4	1 4	„	34	8	2 4	„	65	0	3 4	„	95	4
5	„	5	5	1 5	„	35	9	2 5	„	66	1	3 5	„	96	5
6	„	6	6	1 6	„	36	10	2 6	„	67	2	3 6	„	97	6
7	„	7	7	1 7	„	37	11	2 7	„	68	3	3 7	„	98	7
8	„	8	8	1 8	„	39	0	2 8	„	69	4	3 8	„	99	8
9	„	9	9	1 9	„	40	1	2 9	„	70	5	3 9	„	100	9
10	„	10	10	1 10	„	41	2	2 10	„	71	6	3 10	„	101	10
11	„	11	11	1 11	„	42	3	2 11	„	72	7	3 11	„	102	11
12	„	13	0	1 12	„	43	4	2 12	„	73	8	3 12	„	104	0
13	„	14	1	1 13	„	44	5	2 13	„	74	9	3 13	„	105	1
14	„	15	2	1 14	„	45	6	2 14	„	75	10	3 14	„	106	2
15	„	16	3	1 15	„	46	7	2 15	„	76	11	3 15	„	107	3
16	„	17	4	1 16	„	47	8	2 16	„	78	0	3 16	„	108	4
17	„	18	5	1 17	„	48	9	2 17	„	79	1	3 17	„	109	5
18	„	19	6	1 18	„	49	10	2 18	„	80	2	3 18	„	110	6
19	„	20	7	1 19	„	50	11	2 19	„	81	3	3 19	„	111	7
20	„	21	8	1 20	„	52	0	2 20	„	82	4	3 20	„	112	8
21	„	22	9	1 21	„	53	1	2 21	„	83	5	3 21	„	113	9
22	„	23	10	1 22	„	54	2	2 22	„	84	6	3 22	„	114	10
23	„	24	11	1 23	„	55	3	2 23	„	85	7	3 23	„	115	11
24	„	26	0	1 24	„	56	4	2 24	„	86	8	3 24	„	117	0
25	„	27	1	1 25	„	57	5	2 25	„	87	9	3 25	„	118	1
26	„	28	2	1 26	„	58	6	2 26	„	88	10	3 26	„	119	2
27	„	29	3	1 27	„	59	7	2 27	„	89	11	3 27	„	120	3

THE HUNDREDWEIGHT RECKONER.

1*s.* 1½*d.* per lb., or 126*s.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	31	6	2	0	is	63	0	3	0	is	94	6
1	is	1	1½	1	1	„	32	7½	2	1	„	64	1½	3	1	„	95	7½
2	„	2	3	1	2	„	33	9	2	2	„	65	3	3	2	„	96	9
3	„	3	4½	1	3	„	34	10½	2	3	„	66	4½	3	3	„	97	10½
4	„	4	6	1	4	„	36	0	2	4	„	67	6	3	4	„	99	0
5	„	5	7½	1	5	„	37	1½	2	5	„	68	7½	3	5	„	100	1½
6	„	6	9	1	6	„	38	3	2	6	„	69	9	3	6	„	101	3
7	„	7	10½	1	7	„	39	4½	2	7	„	70	10½	3	7	„	102	4½
8	„	9	0	1	8	„	40	6	2	8	„	72	0	3	8	„	103	6
9	„	10	1½	1	9	„	41	7½	2	9	„	73	1½	3	9	„	104	7½
10	„	11	3	1	10	„	42	9	2	10	„	74	3	3	10	„	105	9
11	„	12	4½	1	11	„	43	10½	2	11	„	75	4½	3	11	„	106	10½
12	„	13	6	1	12	„	45	0	2	12	„	76	6	3	12	„	108	0
13	„	14	7½	1	13	„	46	1½	2	13	„	77	7½	3	13	„	109	1½
14	„	15	9	1	14	„	47	3	2	14	„	78	9	3	14	„	110	3
15	„	16	10½	1	15	„	48	4½	2	15	„	79	10½	3	15	„	111	4½
16	„	18	0	1	16	„	49	6	2	16	„	81	0	3	16	„	112	6
17	„	19	1½	1	17	„	50	7½	2	17	„	82	1½	3	17	„	113	7½
18	„	20	3	1	18	„	51	9	2	18	„	83	3	3	18	„	114	9
19	„	21	4½	1	19	„	52	10½	2	19	„	84	4½	3	19	„	115	10½
20	„	22	6	1	20	„	54	0	2	20	„	85	6	3	20	„	117	0
21	„	23	7½	1	21	„	55	1½	2	21	„	86	7½	3	21	„	118	1½
22	„	24	9	1	22	„	56	3	2	22	„	87	9	3	22	„	119	3
23	„	25	10½	1	23	„	57	4½	2	23	„	88	10½	3	23	„	120	4½
24	„	27	0	1	24	„	58	6	2	24	„	90	0	3	24	„	121	6
25	„	28	1½	1	25	„	59	7½	2	25	„	91	1½	3	25	„	122	[illegible]
26	„	29	3	1	26	„	60	9	2	26	„	92	3	3	26	„	[illegible]	[illegible]
27	„	30	4½	1	27	„	61	10½	2	27	„	93	4½	3	27	„	124	1[illegible]

THE HUNDREDWEIGHT RECKONER.

1*s.* 2*d.* per lb., or 130*s.* 8*d.* per cwt.

lbs.		*s*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	32	8	2	0	is	65	4	3	0	is	98	0
1	is	1	2	1	1	,,	33	10	2	1	,,	66	6	3	1	,,	99	2
2	,,	2	4	1	2	,,	35	0	2	2	,,	67	8	3	2	,,	100	4
3	,,	3	6	1	3	,,	36	2	2	3	,,	68	10	3	3	,,	101	6
4	,,	4	8	1	4	,,	37	4	2	4	,,	70	0	3	4	,,	102	8
5	,,	5	10	1	5	,,	38	6	2	5	,,	71	2	3	5	,,	103	10
6	,,	7	0	1	6	,,	39	8	2	6	,,	72	4	3	6	,,	105	0
7	,,	8	2	1	7	,,	40	10	2	7	,,	73	6	3	7	,,	106	2
8	,,	9	4	1	8	,,	42	0	2	8	,,	74	8	3	8	,,	107	4
9	,,	10	6	1	9	,,	43	2	2	9	,,	75	10	3	9	,,	108	6
10	,,	11	8	1	10	,,	44	4	2	10	,,	77	0	3	10	,,	109	8
11	,,	12	10	1	11	,,	45	6	2	11	,,	78	2	3	11	,,	110	10
12	,,	14	0	1	12	,,	46	3	2	12	,,	79	4	3	12	,,	2	0
13	,,	15	2	1	13	,,	47	10	2	13	,,	80	6	3	13	,,	113	2
14	,,	16	4	1	14	,,	49	0	2	14	,,	81	8	3	14	,,	114	4
15	,,	17	6	1	15	,,	50	2	2	15	,,	82	10	3	15	,,	115	6
16	,,	18	8	1	16	,,	51	4	2	16	,,	84	0	3	16	,,	116	8
17	,,	19	10	1	17	,,	52	6	2	17	,,	85	2	3	17	,,	117	10
18	,,	21	0	1	18	,,	53	8	2	18	,,	86	4	3	18	,,	119	0
19	,,	22	2	1	19	,,	54	10	2	19	,,	87	6	3	19	,,	120	2
20	,,	[illegible]	4	1	20	,,	56	0	2	20	,,	[illegible]	8	3	20	,,	121	4
21	,,	24	6	1	21	,,	57	2	2	21	,,	89	10	3	21	,,	122	6
22	,,	25	8	1	22	,,	58	4	2	22	,,	91	0	3	22	,,	123	8
23	,,	26	10	1	23	,,	59	6	2	23	,,	92	2	3	23	,,	124	10
24	,,	28	0	1	24	,,	60	8	2	24	,,	93	4	3	24	,,	126	0
25	,,	29	2	1	25	,,	61	10	2	25	,,	94	6	3	25	,,	127	2
26	,,	[illegible]	4	1	26	,,	63	4	2	26	,,	95	8	3	26	,,	128	4
27	,,	31	6	1	27	,,	64	2	2	27	,,	96	10	3	27	,,	129	6

THE HUNDREDWEIGHT RECKONER.

1*s.* 2½*d.* per lb., or 135*s.* 4*d.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	33	10	2	0	is	67	8	3	0	is	101	6
1	is	1	2½	1	1	,,	35	0½	2	1	,,	68	10½	3	1	,,	102	8½
2	,,	2	5	1	2	,,	36	3	2	2	,,	70	1	3	2	,,	103	11
3	,,	3	7½	1	3	,,	37	5½	2	3	,,	71	3½	3	3	,,	105	1½
4	,,	4	10	1	4	,,	38	8	2	4	,,	72	6	3	4	,,	106	4
5	,,	6	0½	1	5	,,	39	10½	2	5	,,	73	8½	3	5	,,	107	6½
6	,,	7	3	1	6	,,	41	1	2	6	,,	74	11	3	6	,,	108	9
7	,,	8	5½	1	7	,,	42	3½	2	7	,,	76	1½	3	7	,,	109	11½
8	,,	9	8	1	8	,,	43	6	2	8	,,	77	4	3	8	,,	111	2
9	,,	10	10½	1	9	,,	44	8½	2	9	,,	78	6½	3	9	,,	112	4½
10	,,	12	1	1	10	,,	45	11	2	10	,,	79	9	3	10	,,	113	7
11	,,	13	3½	1	11	,,	47	1½	2	11	,,	80	11½	3	11	,,	114	9½
12	,,	14	6	1	12	,,	48	4	2	12	,,	82	2	3	12	,,	116	0
13	,,	15	8½	1	13	,,	49	6½	2	13	,,	83	4½	3	13	,,	117	2½
14	,,	16	11	1	14	,,	50	9	2	14	,,	84	7	3	14	,,	118	5
15	,,	18	1½	1	15	,,	51	11½	2	15	,,	85	9½	3	15	,,	119	7½
16	,,	19	4	1	16	,,	53	2	2	16	,,	87	0	3	16	,,	120	10
17	,,	20	6½	1	17	,,	54	4½	2	17	,,	88	2½	3	17	,,	122	0½
18	,,	21	9	1	18	,,	55	7	2	18	,,	89	5	3	18	,,	123	3
19	,,	22	11½	1	19	,,	56	9½	2	19	,,	90	7½	3	19	,,	124	5½
20	,,	24	2	1	20	,,	58	0	2	20	,,	91	10	3	20	,,	125	8
21	,,	25	4½	1	21	,,	59	2½	2	21	,,	93	0½	3	21	,,	126	10
22	,,	26	7	1	22	,,	60	5	2	22	,,	94	3	3	22	,,	128	1
23	,,	27	9½	1	23	,,	61	7½	2	23	,,	95	5½	3	23	,,	129	[illegible]
24	,,	29	0	1	24	,,	62	10	2	24	,,	96	8	3	24	,,	130	6
25	,,	30	2½	1	25	,,	64	0½	2	25	,,	97	10½	3	25	,,	131	8
26	,,	31	5	1	26	,,	65	3	2	26	,,	99	[illegible]	3	26	,,	132	11
27	,,	32	7½	1	27	,,	66	5½	2	27	,,	100	3½	3	27	,,	134	1

The Hundredweight Reckoner.

1*s.* 3*d.* per lb., or 140*s.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	35	0	2	0	is	70	0	3	0	is	105	0
1	is	1	3	1	1	,,	36	3	2	1	,,	71	3	3	1	,,	106	3
2	,,	2	6	1	2	,,	37	6	2	2	,,	72	6	3	2	,,	107	6
3	,,	3	9	1	3	,,	38	9	2	3	,,	73	9	3	3	,,	108	9
4	,,	5	0	1	4	,,	40	0	2	4	,,	75	0	3	4	,,	110	0
5	,,	6	3	1	5	,,	41	3	2	5	,,	76	3	3	5	,,	111	3
6	,,	7	6	1	6	,,	42	6	2	6	,,	77	6	3	6	,,	112	6
7	,,	8	9	1	7	,,	43	9	2	7	,,	78	9	3	7	,,	113	9
8	,,	10	0	1	8	,,	45	0	2	8	,,	80	0	3	8	,,	115	0
9	,,	11	3	1	9	,,	46	3	2	9	,,	81	3	3	9	,,	116	3
10	,,	12	6	1	10	,,	47	6	2	10	,,	82	6	3	10	,,	117	6
11	,,	13	9	1	11	,,	48	9	2	11	,,	83	9	3	11	,,	118	9
12	,,	15	0	1	12	,,	50	0	2	12	,,	85	0	3	12	,,	120	0
13	,,	16	3	1	13	,,	51	3	2	13	,,	86	3	3	13	,,	121	3
14	,,	17	6	1	14	,,	52	6	2	14	,,	87	6	3	14	,,	122	6
15	,,	18	9	1	15	,,	53	9	2	15	,,	88	9	3	15	,,	123	9
16	,,	20	0	1	16	,,	55	0	2	16	,,	90	0	3	16	,,	125	0
17	,,	21	3	1	17	,,	56	3	2	17	,,	91	3	3	17	,,	126	3
18	,,	22	6	1	18	,,	57	6	2	18	,,	92	6	3	18	,,	127	6
19	,,	23	9	1	19	,,	58	9	2	19	,,	93	9	3	19	,,	128	9
20	,,	25	0	1	20	,,	60	0	2	20	,,	95	0	3	20	,,	130	0
21	,,	26	3	1	21	,,	61	3	2	21	,,	96	3	3	21	,,	131	3
22	,,	27	6	1	22	,,	62	6	2	22	,,	97	6	3	22	,,	132	6
23	,,	28	9	1	23	,,	63	9	2	23	,,	98	9	3	23	,,	133	9
24	,,	30	0	1	24	,,	65	0	2	24	,,	100	0	3	24	,,	135	0
25	,,	31	3	1	25	,,	66	3	2	25	,,	101	3	3	25	,,	136	3
26	,,	32	6	1	26	,,	67	6	2	26	,,	102	6	3	26	,,	137	6
27	,,	33	9	1	27	,,	68	9	2	27	,,	103	9	3	27	,,	138	9

THE HUNDREDWEIGHT RECKONER.

s. 3½d. per lb., or 144s. 8d. per cwt.

lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.
				1	0	is	36	2	2	0	is	72	4	3	0	is	108	6
1	is	1	3½	1	1	,,	37	5½	2	1	,,	73	7½	3	1	,,	109	9½
2	,,	2	7	1	2	,,	38	9	2	2	,,	74	11	3	2	,,	111	1
3	,,	3	10½	1	3	,,	40	0½	2	3	,,	76	2½	3	3	,,	112	4½
4	,,	5	2	1	4	,,	41	4	2	4	,,	77	6	3	4	,,	113	8
5	,,	6	5½	1	5	,,	42	7½	2	5	,,	78	9½	3	5	,,	114	11½
6	,,	7	9	1	6	,,	43	11	2	6	,,	80	1	3	6	,,	116	3
7	,,	9	0½	1	7	,,	45	2½	2	7	,,	81	4½	3	7	,,	117	6½
8	,,	10	4	1	8	,,	46	6	2	8	,,	82	8	3	8	,,	118	10
9	,,	11	7½	1	9	,,	47	9½	2	9	,,	83	11½	3	9	,,	120	1½
10	,,	12	11	1	10	,,	49	1	2	10	,,	85	3	3	10	,,	121	5
11	,,	14	2½	1	11	,,	50	4½	2	11	,,	86	6½	3	11	,,	122	8½
12	,,	15	6	1	12	,,	51	8	2	12	,,	87	10	3	12	,,	[illegible]	0
13	,,	16	9½	1	13	,,	52	11½	2	13	,,	89	1½	3	13	,,	125	3½
14	,,	18	1	1	14	,,	54	3	2	14	,,	90	5	3	14	,,	126	7
15	,,	19	4½	1	15	,,	55	6½	2	15	,,	91	8½	3	15	,,	127	10½
16	,,	20	8	1	16	,,	56	10	2	16	,,	93	0	3	16	,,	129	2
17	,,	21	11½	1	17	,,	58	1½	2	17	,,	94	3½	3	17	,,	130	5½
18	,,	23	3	1	18	,,	59	5	2	18	,,	95	7	3	18	,,	131	9
19	,,	24	6½	1	19	,,	60	8½	2	19	,,	96	10½	3	19	,,	133	0½
20	,,	25	10	1	20	,,	62	0	2	20	,,	98	2	3	20	,,	134	4
21	,,	27	1½	1	21	,,	63	3½	2	21	,,	99	5½	3	[illegible]	,,	135	7½
22	,,	28	5	1	22	,,	64	7	2	22	,,	100	9	3	22	,,	136	11
23	,,	29	8½	1	23	,,	65	10½	2	23	,,	102	0½	3	23	,,	138	2½
24	,,	31	0	1	24	,,	67	2	2	24	,,	103	4	3	24	,,	139	6
25	,,	32	3½	1	25	,,	68	5½	2	25	,,	104	7½	3	25	,,	140	9½
26	,,	33	7	1	26	,,	69	9	2	26	,,	105	[illegible]	3	26	,,	142	1
27	,,	34	10½	1	27	,,	71	0½	2	27	,,	107	2½	3	27	,,	143	4½

The Hundredweight Reckoner.

1*s.* 4*d.* per lb., or 149*s.* 4*d.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	37	4	2	0	is	74	8	3	0	is	112	0
1	is	1	4	1	1	,,	38	8	2	1	,,	76	0	3	1	,,	113	4
2	,,	2	8	1	2	,,	40	0	2	2	,,	77	4	3	2	,,	114	8
3	,,	4	0	1	3	,,	41	4	2	3	,,	78	8	3	3	,,	116	0
4	,,	5	4	1	4	,,	42	8	2	4	,,	80	0	3	4	,,	117	4
5	,,	6	8	1	5	,,	44	0	2	5	,,	81	4	3	5	,,	118	8
6	,,	8	0	1	6	,,	45	4	2	6	,,	82	8	3	6	,,	120	0
7	,,	9	4	1	7	,,	46	8	2	7	,,	84	0	3	7	,,	121	4
8	,,	10	8	1	8	,,	48	0	2	8	,,	85	4	3	8	,,	122	8
9	,,	12	0	1	9	,,	49	4	2	9	,,	86	8	3	9	,,	124	0
10	,,	13	4	1	10	,,	50	8	2	10	,,	88	0	3	10	,,	125	4
11	,,	14	8	1	11	,,	52	0	2	11	,,	89	4	3	11	,,	126	8
12	,,	16	0	1	12	,,	43	4	2	12	,,	90	8	3	12	,,	128	0
13	,,	17	4	1	13	,,	54	8	2	13	,,	92	0	3	13	,,	129	4
14	,,	18	8	1	14	,,	56	0	2	14	,,	93	4	3	14	,,	130	8
15	,,	20	0	1	15	,,	57	4	2	15	,,	94	8	3	15	,,	132	0
16	,,	21	4	1	16	,,	58	8	2	16	,,	96	0	3	16	,,	133	4
17	,,	22	8	1	17	,,	60	0	2	17	,,	97	4	3	17	,,	134	8
18	,,	24	0	1	18	,,	61	4	2	18	,,	98	8	3	18	,,	136	0
19	,,	25	4	1	19	,,	62	8	2	19	,,	100	0	3	19	,,	137	4
20	,,	26	8	1	20	,,	64	0	2	20	,,	101	4	3	20	,,	138	8
21	,,	28	0	1	21	,,	65	4	2	21	,,	102	8	3	21	,,	140	0
22	,,	29	4	1	22	,,	66	8	2	22	,,	104	0	3	22	,,	141	4
23	,,	30	8	1	23	,,	68	0	2	23	,,	105	4	3	23	,,	112	8
24	,,	32	0	1	24	,,	69	4	2	24	,,	106	8	3	24	,,	114	0
25	,,	33	4	1	25	,,	70	8	2	25	,,	108	0	3	25	,,	145	4
26	,,	34	8	1	26	,,	72	0	2	26	,,	109	4	3	26	,,	146	8
27	,,	36	0	1	27	,,	73	4	2	27	,,	110	8	3	27	,,	148	0

THE HUNDREDWEIGHT RECKONER.

1s. 4½d. per lb., or 154s. per cwt.

l.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.
				1	0	is	38	6	2	0	is	77	0	3	0	is	115	6
	is	1	4½	1	1	,,	39	10½	2	1	,,	78	4½	3	1	,,	116	10½
	,,	2	9	1	2	,,	41	3	2	2	,,	79	9	3	2	,,	118	3
	,,	4	1½	1	3	,,	42	7½	2	3	,,	81	1½	3	3	,,	119	7½
	,,	5	6	1	4	,,	44	0	2	4	,,	82	6	3	4	,,	121	0
	,,	6	10½	1	5	,,	45	4½	2	5	,,	83	10½	3	5	,,	122	4½
	,,	8	3	1	6	,,	46	9	2	6	,,	85	3	3	6	,,	123	9
	,,	9	7½	1	7	,,	48	1½	2	7	,,	86	7½	3	7	,,	125	1½
	,,	11	0	1	8	,,	49	6	2	8	,,	88	0	3	8	,,	126	6
	,,	12	4½	1	9	,,	50	10½	2	9	,,	89	4½	3	9	,,	127	10½
	,,	13	9	1	10	,,	52	3	2	10	,,	90	9	3	10	,,	129	3
	,,	15	1½	1	11	,,	53	7½	2	11	,,	92	1½	3	11	,,	130	7½
	,,	16	6	1	12	,,	55	0	2	12	,,	93	6	3	12	,,	132	0
	,,	17	10½	1	13	,,	56	4½	2	13	,,	94	10½	3	13	,,	133	4½
	,,	19	3	1	14	,,	57	9	2	14	,,	96	3	3	14	,,	134	9
	,,	20	7½	1	15	,,	59	1½	2	15	,,	97	7½	3	15	,,	136	1½
	,,	22	0	1	16	,,	60	6	2	16	,,	99	0	3	16	,,	137	6
	,,	23	4½	1	17	,,	61	10½	2	17	,,	100	4½	3	17	,,	138	10½
	,,	24	9	1	18	,,	63	3	2	18	,,	101	9	3	18	,,	140	3
	,,	26	1½	1	19	,,	64	7½	2	19	,,	103	1½	3	19	,,	141	7½
	,,	27	6	1	20	,,	66	0	2	20	,,	104	6	3	20	,,	143	0
	,,	28	10½	1	21	,,	67	4½	2	21	,,	105	10½	3	21	,,	144	4½
	,,	30	3	1	22	,,	68	9	2	22	,,	107	3	3	22	,,	145	9
	,,	31	7½	1	23	,,	70	1½	2	23	,,	108	7½	3	23	,,	147	1½
	,,	33	0	1	24	,,	71	6	2	24	,,	110	0	3	24	,,	148	6
	,,	34	4½	1	25	,,	72	10½	2	25	,,	111	4½	3	25	,,	149	10½
	,,	35	9	1	26	,,	74	3	2	26	,,	112	9	3	26	,,	151	3
	,,	37	1½	1	27	,,	75	7½	2	27	,,	114	1½	3	27	,,	152	7½

THE HUNDREDWEIGHT RECKONER.

1*s.* 5*d.* per lb., or 158*s.* 8*d.* per cwt.

lbs.	s.	d.	qrs.	lbs.	s.	d.	qrs.	lbs.	s.	d.	qrs.	lbs.	s.	d.
			1	0 is	39	8	2	0 is	79	4	3	0 is	119	0
1 is	1	5	1	1 ,,	41	1	2	1 ,,	80	9	3	1 ,,	120	5
2 ,,	2	10	1	2 ,,	42	6	2	2 ,,	82	2	3	2 ,,	121	10
3 ,,	4	3	1	3 ,,	43	11	2	3 ,,	83	7	3	3 ,,	123	3
4 ,,	5	8	1	4 ,,	45	4	2	4 ,,	85	0	3	4 ,,	124	8
5 ,,	7	1	1	5 ,,	46	9	2	5 ,,	86	5	3	5 ,,	126	1
6 ,,	8	6	1	6 ,,	48	2	2	6 ,,	87	10	3	6 ,,	127	6
7 ,,	9	11	1	7 ,,	49	7	2	7 ,,	89	3	3	7 ,,	128	11
8 ,,	11	4	1	8 ,,	51	0	2	8 ,,	90	8	3	8 ,,	130	4
9 ,,	12	9	1	9 ,,	52	5	2	9 ,,	92	1	3	9 ,,	131	9
10 ,,	14	2	1	10 ,,	53	10	2	10 ,,	93	6	3	10 ,,	133	2
11 ,,	15	7	1	11 ,,	55	3	2	11 ,,	94	11	3	11 ,,	134	7
12 ,,	17	0	1	12 ,,	56	8	2	12 ,,	96	4	3	12 ,,	136	0
13 ,,	18	5	1	13 ,,	58	1	2	13 ,,	97	9	3	13 ,,	137	5
14 ,,	19	10	1	14 ,,	59	6	2	14 ,,	99	2	3	14 ,,	138	10
15 ,,	21	3	1	15 ,,	60	11	2	15 ,,	100	7	3	15 ,,	140	3
16 ,,	22	8	1	16 ,,	62	4	2	16 ,,	102	0	3	16 ,,	141	8
17 ,,	24	1	1	17 ,,	63	9	2	17 ,,	103	5	3	17 ,,	143	1
18 ,,	25	6	1	18 ,,	65	2	2	18 ,,	104	10	3	18 ,,	144	6
19 ,,	26	11	1	19 ,,	66	7	2	19 ,,	106	3	3	19 ,,	145	11
20 ,,	28	4	1	20 ,,	68	0	2	20 ,,	107	8	3	20 ,,	147	4
21 ,,	29	9	1	21 ,,	69	5	2	21 ,,	109	1	3	21 ,,	148	9
22 ,,	31	2	1	22 ,,	70	10	2	22 ,,	110	6	3	22 ,,	150	2
23 ,,	32	7	1	23 ,,	72	3	2	23 ,,	111	11	3	23 ,,	51	7
24 ,,	34	0	1	24 ,,	73	8	2	24 ,,	113	4	3	24 ,,	153	0
25 ,,	35	5		25 ,,	75	1	2	25 ,,	114	9	3	25 ,,	154	5
26 ,,	36	10	1	26 ,,	76	6	2	26 ,,	116	2	3	26 ,,	155	10
27 ,,	38	3	1	27 ,,	77	11	2	27 ,,	117	7	3	27 ,,	157	3

The Hundredweight Reckoner.

1*s.* 5½*d.* per lb., or 163*s.* 4*d.* per cwt.

lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*	qrs.	lbs.		*s.*	*d.*
				1	0	is	40	10	2	0	is	81	8	3	0	is	122	6
1	is	1	5½	1	1	,,	42	3½	2	1	,,	83	1½	3	1	,,	123	11½
2	,,	2	11	1	2	,,	43	9	2	2	,,	84	7	3	2	,,	125	5
3	,,	4	4½	1	3	,,	45	2½	2	3	,,	86	0½	3	3	,,	126	10½
4	,,	5	10	1	4	,,	46	8	2	4	,,	87	6	3	4	,,	128	4
5	,,	7	3½	1	5	,,	48	1½	2	5	,,	88	11½	3	5	,,	129	9½
6	,,	8	9	1	6	,,	49	7	2	6	,,	90	5	3	6	,,	131	3
7	,,	10	2½	1	7	,,	51	0½	2	7	,,	91	10½	3	7	,,	132	8½
8	,,	11	8	1	8	,,	52	6	2	8	,,	93	4	3	8	,,	134	2
9	,,	13	1½	1	9	,,	53	11½	2	9	,,	94	9½	3	9	,,	135	7½
10	,,	14	7	1	10	,,	55	5	2	10	,,	96	3	3	10	,,	137	1
11	,,	16	0½	1	11	,,	56	10½	2	11	,,	97	8½	3	11	,,	138	6½
12	,,	17	6	1	12	,,	58	4	2	12	,,	99	2	3	12	,,	140	0
13	,,	18	11½	1	13	,,	59	9½	2	13	,,	100	7½	3	13	,,	141	5½
14	,,	20	5	1	14	,,	61	3	2	14	,,	102	1	3	14	,,	142	11
15	,,	21	10½	1	15	,,	62	8½	2	15	,,	103	6½	3	15	,,	144	4½
16	,,	23	4	1	16	,,	64	2	2	16	,,	105	0	3	16	,,	145	10
17	,,	24	9½	1	17	,,	65	7½	2	17	,,	106	5½	3	17	,,	147	3½
18	,,	26	3	1	18	,,	67	1	2	18	,,	107	11	3	18	,,	148	9
19	,,	27	8½	1	19	,,	68	6½	2	19	,,	109	4½	3	19	,,	150	2½
20	,,	29	2	1	20	,,	70	0	2	20	,,	110	10	3	20	,,	151	8
21	,,	30	7½	1	21	,,	71	5½	2	21	,,	112	3½	3	21	,,	153	1½
22	,,	32	1	1	22	,,	72	11	2	22	,,	113	9	3	22	,,	154	7
23	,,	33	6½	1	23	,,	74	4½	2	23	,,	115	2½	3	23	,,	156	0½
24	,,	35	0	1	24	,,	75	10	2	24	,,	116	8	3	24	,,	157	6
25	,,	36	5½	1	25	,,	77	3½	2	25	,,	118	1½	3	25	,,	158	11½
26	,,	37	11	1	26	,,	78	9	2	26	,,	119	7	3	26	,,	160	5
27	,,	39	4½	1	27	,,	80	2½	2	27	,,	121	0½	3	27	,,	161	10½

The Hundredweight Reckoner.

1*s.* 6*d.* per lb., or 168*s.* per cwt.

lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs.	lbs.		s.	d.	qrs	lbs.		s.	d.
				1	0	is	42	0	2	0	is	84	0	3	0	is	126	0
1	is	1	6	1	1	,,	43	6	2	1	,,	85	6	3	1	,,	127	6
2	,,	3	0	1	2	,,	45	0	2	2	,,	87	0	3	2	,,	129	0
3	,,	4	6	1	3	,,	46	6	2	3	,,	88	6	3	3	,,	130	6
4	,,	6	0	1	4	,,	48	0	2	4	,,	90	0	3	4	,,	132	0
5	,,	7	6	1	5	,,	49	6	2	5	,,	91	6	3	5	,,	133	6
6	,,	9	0	1	6	,,	51	0	2	6	,,	93	0	3	6	,,	135	0
7	,,	10	6	1	7	,,	52	6	2	7	,,	94	6	3	7	,,	136	6
8	,,	12	0	1	8	,,	54	0	2	8	,,	96	0	3	8	,,	138	0
9	,,	13	6	1	9	,,	55	6	2	9	,,	97	6	3	9	,,	139	6
10	,,	15	0	1	10	,,	57	0	2	10	,,	99	0	3	10	,,	141	0
11	,,	16	6	1	11	,,	58	6	2	11	,,	100	6	3	11	,,	142	6
12	,,	18	0	1	12	,,	60	0	2	12	,,	102	0	3	12	,,	144	0
13	,,	19	6	1	13	,,	61	6	2	13	,,	103	6	3	13	,,	145	6
14	,,	21	0	1	14	,,	63	0	2	14	,,	105	0	3	14	,,	147	0
15	,,	22	6	1	15	,,	64	6	2	15	,,	106	6	3	15	,,	148	6
16	,,	24	0	1	16	,,	66	0	2	16	,,	108	0	3	16	,,	150	0
17	,,	25	6	1	17	,,	67	6	2	17	,,	109	6	3	17	,,	151	6
18	,,	27	0	1	18	,,	69	0	2	18	,,	111	0	3	18	,,	153	0
19	,,	28	6	1	19	,,	70	6	2	19	,,	112	6	3	19	,,	154	6
20	,,	30	0	1	20	,,	72	0	2	20	,,	114	0	3	20	,,	156	0
21	,,	31	6	1	21	,,	73	6	2	21	,,	115	6	3	21	,,	157	6
22	,,	33	0	1	22	,,	75	0	2	22	,,	117	0	3	22	,,	159	0
23	,,	34	6	1	23	,,	76	6	2	23	,,	118	6	3	23	,,	160	6
24	,,	36	0	1	24	,,	78	0	2	24	,,	120	0	3	24	,,	162	0
25	,,	37	6	1	25	,,	79	6	2	25	,,	121	6	3	25	,,	163	6
26	,,	39	0	1	26	,,	81	0	2	26	,,	123	0	3	26	,,	165	0
27	,,	40	6	1	27	,,	82	6	2	27	,,	124	6	3	27	,,	166	6

ON THE SUBSIDIARY BOOKS OF THE WORKSHOP.

PERHAPS at no former period has there been a stronger desire than at present, among manufacturers, to arrive at *costs* and prevent *waste* in the workshops. The more costly the metals, the greater necessity there is for checks. The greater the competition in a trade, the greater necessity for arriving accurately at prime costs.

We hope to place this important subject clearly before the reader, keeping out of view the ordinary books of an accountant, such as day-books and ledgers: these are understood by book-keepers, and require no remarks here. Should the reader be ignorant of such, he can be supplied by any bookseller with works on the subject. We only purpose treating of subsidiary or workshop books. First,

THE CASTERS' BOOK.

EVERY morning the casters have *their metals weighed* out to them from the store, and booked as follows:—

GIVEN OUT.

Date.	Copper.	Zinc.	Brass	Tin.	Lead.	Total.		
1868.	lbs.	lbs.	lbs.	lbs.	lbs.	cwt.	qrs.	lbs.
April 3	112	56	84	4	14	2	1	2[illegible]
" 4	200	100	35	4	10	3	0	14

On the opposite page, and in the same lines, are entered every evening the returns in the following manner:—

RETURNED.

Date.	Fine Castings.	Commn. Castings.	Gates	Copr.	Zinc.	Tin.	Lead.	Total.			Loss.
1868.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	cwt.	qrs.	lbs	per cent.
Apr. 3	200	24	33	4	2	1	2	2	1	14	2·64
„ 4	200	80	56	3	1	0	1	3	0	5	2·65

The difference between the totals of the given-outs and the returns is entered in the last column, headed by Loss, so as to show the percentage of loss every day. Thus, on April 3rd, on 266 lbs. of returns there is a loss of 7 lbs., which comes to 2·64 per cent. On April 4th there are 9 lbs. of loss on 341 lbs., which comes to 2·65 per cent.

At the bottom of every page the columns containing castings on returned side are added up, and the summation carried over to next page; and this is repeated until the end of each month, when the result will show the amount of castings produced during the month. At the end of each month obtain the following results:—

1st. Total weight of castings produced;
2nd. Average loss per cent.;
3rd. The proportions between copper, zinc, &c., used.

These results are entered into a result-book, to be hereafter explained

THE MOULDING AND CASTING SHOPS EXPENSES BOOK.

In this book are entered, under separate headings, every expense inside the casting and moulding shops, except for new plant. Thus, sands, coke, petties, wages, rent, interest on plant, &c., are made up to the end of every month, taking care to carry to the following month the quantities in stock, and not to include these quantities in the result, which result is carried to the result-book as

4th. The expenses of moulding and casting.

The interest on plant requires to be rated at ten per cent. Such articles as brushes, which go soon to waste, are not included in plant, but belong to the general expenses.

THE RESULT-BOOK.

In this book are collected all the results of other books, under headings, and bearing dates. Thus, from the two books already named we collect—

1st. The total weight of castings produced;
2nd. Average loss per cent.;
3rd. The proportion between copper, zinc, &c., used;
4th. The expenses of moulding and casting—
A. Wages;
B. All other expenses.

Having arrived at these results, we are able to

arrive at the net cost of the castings. Of course the price paid at the time for the ingot metals will be known. Thus :—

1st. Total weight produced, one month, 3 tons 1 cwt
3rd. The proportions and prices being,—

			£	s.	d
2 tons copper	at	£80	160	0	
1 ton zinc	,,	28	28	0	
84 lbs. tin	,,	100 per ton . .	3	15	
28 lbs. lead	,,	28 ,, . .	0	7	
			192	2	
2nd. Average loss 2·75 per cent.		. . . .	5	5	
4th. Wages and other expenses		. . . .	115	15	
			£313	2	

Dividing this sum by the weight produced, we arrive at elevenpence per pound as the net cost of the castings produced ; the operation being, 3 tons 1 cwt equals 6,832 lbs., and £313 2*s*. 8*d*. equals 75,152 pence.

```
6832)75152(11d per pound.
     6832
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      6832
      6832
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It must now be perfectly clear that the same principle carried out in each department will yield like results.

THE DIPPING AND LACQUERING BOOK.

In this book everything used during one month, and all wages paid during the same period, together with

proportion of rent and interest on plant, are carried to result-book as—

5th. Expenses, dipping and lacquering—
A. Wages,
B. All other expenses.

Then all goods passing from these departments; being measured and reduced to superficial feet, are carried to result-book as—

6th. Superficial feet dipped and lacquered.

Then the expenses, divided by superficial feet, gives the cost of dipping and lacquering per foot.

THE FINISHERS' BOOK.

In this book are entered all wages and every other expense, including rent and interest on plant; and from this book are carried monthly to the result-book—

7th. Wages;
8th. All other expenses.

Under wages we only include wages paid to producers, that is, to those whose time is entered against the job at which they are working. The wages of non-producers, such as labourers, are entered along with other general expenses. Except where there is a blast-furnace, the whole expense of the engine is charged among expenses. Having arrived at these results, the following proportion is struck:—

As one month's wages are to one month's expenses, so is one pound of wages to the expenses on one pound of wages.

THE TIME AND MATERIAL BOOK.

In this book are entered together the workmen's time at their respective jobs, or the sum allowed if on piece-work, and all the materials used at said jobs.

We have now gone through all the books necessary to arrive exactly at the cost of work, from the moment the work is given out from the store or warehouse, until it returns to the store or warehouse finished; and we have only to express the hope that the arrangement set forth here will be found of service to the reader.

There is connected with the question of cost another question of too much importance to be treated of in a few pages, and which, therefore, we cannot enter upon here, but simply throw it out that the reader may think over it. The question is, What *should* the work cost?—and this question is quite different from, What *does* the work cost?

SUNDRY PRACTICAL RECEIPTS.

For Cementing Brass Letters to Glass Windows :—

16 parts copal varnish,
5 parts drying oil,
3 parts turpentine,
3 parts oil of ditto,
5 parts liquid glue,
10 parts stucco.

For Fixing Metal to Leather :—

Wash the metal in hot gelatine,
Steep the leather in hot gall-nut infusion,
And unite while hot.

For Fixing Metal to Marble, Stone, or Wood :—

4 parts carpenters' glue,
1 part Venice turpentine.

For Fixing Glass to Glass :—

A. Marine glue gives a black join.
B. Curd of milk,
Quicklime,
Camphor.

For Coating Acid Troughs :—

1 part pitch,
1 part rosin,
1 part plaster of Paris (perfectly dry),
Melted together.

For Cold Tinning :—

Tin + mercury :—Mix till soft and friable, clean with spirits of salt, and, while moist, rub on the above amalgam, and after the metal is tinned evaporate the mercury by heat.

N.B.—Avoid using the above for dishes or pans.

For Cold Silvering :—

1 part chloride of silver,
3 parts pearlash,
1½ parts common salt,
1 part whiting.

Clean the metal with soft leather or cork, moisten the metal with water, and rub on the above. After the metal is silvered, wash in hot water slightly alkaline.

PROPERTIES OF MATERIALS, BY VARIOUS AUTHORITIES.

Metals.

Name.	Specific gravity. Water=1000.	Melting points in degrees of Fahrenheit.	Contraction in parts of an inch per lineal foot from the fluid to the average temperature in solid state.	Ultimate cohesive strength of an inch sq. prism in tons.	Scale of wire-drawing ductility.	Scale of laminable ductility.	Ratio of hardness.	Scale as conductors of electricity.	Ratio of power in the conduction of heat.
Platinum	19500	3280	—	—	3	5	—	—	3·8
Pure Gold	19258	2016	—	—	1	1	1·8	3	10·0
Mercury	13500	—	—	—	—	—	—	—	—
Lead	11352	612	·319	·81	8	7	1·0	6	1·8
Pure Silver	10474	1873	—	—	2	2	2·4	2	9·7
Bismuth	9823	476	·156	1·45	—	—	2·0	—	—
Copper, cast	8788	1996	·193	8·51	—	—	—	—	—
,, wrought	8910	—	—	15·08	5	3	2·8	1	8·9
Brass, cast	7824	1900	·210	8·01	—	—	to any degree	—	—
,, sheet	8396	—	—	12·23	6	6	—	—	8·6
Iron, cast	7264	2786	125	7·87	—	—	to any degree	—	—
,, bar	7700	—	·137	25·00	4	8	4·7	4	3·7
Steel, soft	7833	—	·133	57·91	—	—	—	—	—
,, hard	7816	—	—	—	—	—	to any degree	—	—
Tin, cast	7291	442	·278	2·11	8	4	1·2	5	3·0
Zinc, cast	7190	773	329	5·06	7	8	1·6	7	3·6

Stones, Earths, &c.

Name.	Specific gravity.	Weight of a cubic foot in lbs.	Cubic feet in a ton.	Tons required to crush 1½-inch cubes.
Marble, average	2720	170·00	13	9·25
Granite, ,,	2651	165·68	13¼	6·2
Purbeck stone	2601	162·56	13¾	9·0
Portland ,,	2570	160·62	14	4·5
Bristol ,,	2554	159·62	14	—
Millstone	2484	155·25	14½	—
Paving stone	2415	150·93	14¼	5·7
Craigleith stone	2362	147·62	15	5·0
Grindstone	2143	133·93	16¾	6·6
Chalk, Brit.	2781	173·81	12¾	0·5
Brick	2000	125·00	17	0·8
Coal, Scotch	1300	81·15	27½	—
,, Newcastle	1270	79·37	27¼	—
,, Staffordsh.	1240	77·50	29	—
,, Cannel	1238	77·37	29	—

IMPERIAL STANDARD WIRE-GAUGE OF SIZES, WEIGHTS, LENGTHS, AND BREAKING STRAINS OF IRON WIRE, PREPARED BY THE IRON AND STEEL WIRE MANUFACTURERS' ASSOCIATION.

Size on Wire Gauge.	Diameter. Inch.	Diameter. Millimetres.	Sectional Area in square inches.	Weight of. 100 Yards.	Weight of. Mile.	Length of cwt.	Breaking Strains. Annealed.	Breaking Strains. Bright.	Size on Wire Gauge.
				lbs.	lbs.	yds	lbs.	lbs.	
7/0	·500	12·7	·1963	193·4	3404	58	10470	15700	7/0
6/0	·464	11·8	·1691	166·5	2930	67	9017	13525	6/0
5/0	·432	11	·1466	144·4	2541	78	7814	[illegible]	5/0
4/0	·400	10·2	·1257	123·8	2179	91	6702	10052	4/0
3/0	·372	9·4	·1087	107·1	1885	105	5796	8694	3/0
2/0	·348	8·8	·0951	93·7	1649	120	5072	7608	2/0
1/0	·324	8·2	·0824	81·2	1429	138	4397	6595	1/0
1	·300	7·6	·0707	69·6	1225	161	3770	5655	1
2	·276	7	·0598	58·9	1037	190	3190	4785	2
3	·252	6·4	·0499	49·1	864	228	2660	3990	3
4	·232	5·9	·0423	41·6	732	269	2254	3381	4
5	·212	5·4	·0353	34·8	612	322	1883	2824	5
6	·192	4·9	·0290	28·5	502	393	1544	2316	6
7	·176	4·5	·0243	24	422	467	1298	1946	7
8	·160	4·1	·0201	19·8	348	566	1072	1608	8
9	·144	3·7	·0163	16	282	700	869	1303	9
10	·128	3·3	·0129	12·7	223	882	687	1030	10
11	·116	3	·0106	10·4	183	1077	564	845	11
12	·104	2·6	·0085	8·4	148	1333	454	680	12
13	·092	2·3	·0066	6·5	114	1723	355	532	13
14	·080	2	·0050	5	88	2240	268	402	14
15	·072	1·8	·0041	4	70	2800	218	326	15
16	·064	1·6	·0032	3·2	56	3500	172	257	16
17	·056	1·4	·0025	2·4	42	4667	131	197	17
18	·048	1·2	·0018	1·8	32	6222	97	145	18
19	·040	1	·0013	1·2	21	9333	67	100	19
20	·036	0·9	·0010	1	18	11200	55	82	20

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